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The Steel Age

"PEOPLE cannot look forward to posterity who never look back to their ancestors," quoted the Hon. R. G. Lyttelton in his Presidential Address to the Iron and Steel Institute last month, when he surveyed the social consequences of iron and steel. Mr. Lyttelton was mainly concerned with the part which these closely related materials had played in the development of civilisation as we know it to-day, and for those of us who take iron and steel so much for granted it put matters in their proper perspective to be reminded that, although man has existed for some 500,000 years, the earliest known iron tool was made as recently as 3000 B.C., and that the steel industry as we know it to-day had its beginnings barely a hundred years ago with the perfection of the Bessemer process of steelmaking. Some of the points made by Mr. Lyttelton for the claim that no other single element has exercised such a profound influence on the social organisation of mankind are outlined below, with particular reference to the United Kingdom.

It cannot be claimed that iron was the dominant influence in the first emergence of man from primeval barbarism. That took place in the Stone Age, but the first use of metal, by increasing substantially the productive power of human effort, both in agriculture and war, was largely responsible for the transformation of man from a hunter to a farmer, and he was prompted to found settlements in districts where metals were available. Thus urban civilisation was initiated along the edge of the Nile and in Syria without the help of iron, but the development of urbanisation to its present stage would have been impossible without the transport and communications which iron and steel alone made possible.

The earliest iron remains are now accepted as being of meteoric origin, and the beginning of the Iron Age is generally fixed at about 1400 B.C., the earliest centre of production being in Asia Minor. The iron produced in primitive furnaces was a plastic lump and was purified by reheating and continual hammering to squeeze out the slag. This material was too costly for general use, and iron pots, spits and frying pans were classed among the Crown Jewels, even in the fourteenth century, although they may, of course, have been of special and elaborate fabrication.

With the development of goatskin bellows operated by the feet of the workers, an artificial draught could be used and much higher furnace temperatures were attained, but it was not until the application of the water wheel to operate the bellows, *ca.* 1340, that cast iron was first produced in Britain. The iron industry developed largely in Kent, Surrey and Sussex, because of the hardwood forests there for the provision of charcoal, but alarm arose in Elizabeth's reign that the reserves of timber for building naval vessels were being denuded to a dangerous extent, and the use of charcoal in ironmaking was prohibited in 1585. The industry suffered a steady decline until, in the early years of the eighteenth century, Abram Darby succeeded in making iron in a blast furnace using coke. As a result, the iron industry was transferred to the coalfields. The full benefit of Darby's process awaited the development of the steam engine, which was, in turn, facilitated by Darby's invention. These joint developments were largely responsible for the Industrial Revolution, as the application of power to what had formerly been handicrafts laid the foundation of the factory system, with its incalculable influence on the creation of a new social order.

It was difficult to find financial resources sufficient to take advantage of the flood of inventions which followed the development of mechanical power, demands far exceeding the resources of individuals. Fortunately, however, the Bank of England had been formed at the end of the seventeenth century, and this made possible the investment in industry of the savings of those not directly engaged in it.

One of the characteristics of the Industrial Revolution was the rapidity with which inventions that proved complementary in the development of the industrial system followed one another. In the iron and steel field there were those of Darby, Huntsman, Cort, Neilson, Heath and Mushet—all before 1850—and the foundation of the present day steel industry was laid when Bessemer invented the convertor, Siemens the open-hearth process, and Gilchrist and Thomas the basic lining which enabled high phosphorus pig iron to be made into steel in a convertor. These discoveries were matched by others in manufacturing industries, resulting from the application of power to handicrafts, only made possible by the production of iron and steel in quantity. The net effect of all those developments within a century was to change completely the conditions of life for millions of mankind throughout the world.

The development of the railways went hand in hand with progress in iron and steel making, and in 1881 more than half the steel production of the world was used for railway track. The assembly of people and materials promptly and economically wherever they were required was facilitated by the improved transport, and as a result production was simplified and markets extended, so that costs were reduced, employment increased, and the standard of life raised ultimately for the nation as a whole. In shipping, too, the steel industry has played an important part, whilst developments in alloy steels have made possible the design of high power/weight ratio aero engines of both piston and jet types. The full social and economic effects of high-speed aircraft is not yet determinable, but it may prove to be equally as important as was the impact of the railways in the nineteenth century.

The increase in the population of the United Kingdom from 8 millions in 1740 to 50 millions to-day could not

have been supported without the development of transport and productive machinery, and the application of mechanical power to manufacturing industry and agriculture, which steel alone made possible. The increase is not, of course, directly related to the production of steel, but rather to the advance of human knowledge in all factors concerning our material civilisation, including medicine, health and hygiene generally. This would not have been possible without the increase in productivity and creation of wealth brought about by the conversion of the material resources of the earth to the service of man. This in turn, has depended on the application of steel to the creation of prime movers and of power to manufacturing machinery, tools, etc., all based on the production of steel of varying qualities to suit the services required. Thus it is obvious that the rate of consumption of steel per head of the population is some measure of the rate of material development of a country. On this basis, the United States heads the list with 1,135 ingot lb. per head, followed by Sweden (778), Canada (739), United Kingdom (706), Australia (679) and Germany (661).

So much for the Steel Age to date. What of the future? The important advances that have already been made in the development of steels to meet extreme limits of stress at high temperatures, the reduction of corrosion under service conditions, and the great advance in the understanding of metallurgical phenomena governing the physical and chemical qualities of iron and other metals, have greatly extended the potentialities of the Steel Age. Light alloys have certain advantages in their physical capacity to give high weight/service ratios, but, in general, the cost at present prevents them from being a serious rival to steel. The influence of the industry on the development of our material civilisation is thus paramount. It will, no doubt, increase at a growing pace over an ever-wider area of the world, as the collaboration of all concerned becomes more effective in bringing the knowledge and experience of each to the notice of all.

B.C.I.R.A. Continental Visit

THE first post-war visit organised by the British Cast Iron Research Association of representatives of member-firms to Europe took place last month, the total number participating approaching 60. Two parties were arranged, making use of weekends for travelling to and from the Continent, so that each visit could be confined to one working week, during which ten foundries were visited, besides other visits arranged for small groups.

The visit centred around installations of the hot-blast cupola, every commercially available form of which, with one exception, was inspected. The warmest thanks of the Association and of the participants are due to the firms concerned for permitting the visits and for their hospitality.

The opening visit was to the large Cockerill foundry at Seraing, Liège, followed by one to the C.G. des Conduites d'Eau, Les Venes, Liège, where two cupolas, the larger having 10 tons/hr. capacity, are normally in operation. The parties then proceeded to Germany, where the first plant to be seen was the well-known Goetzewerke at Burscheid, makers of single-cast and centrifugally-cast piston rings. At the works, the visitors had an opportunity of seeing a hot-blast furnace fitted with the Schack type of recuperator. The next visit was to the Economiser Werke at Hilden, where their own (the V.E.W.) design of plant was seen; after this visit the parties dined with the Company. On the third day the parties divided, one to the malleable foundry of Engels and Wenke, Velbert, and the other to the Steinmüller works at Gummersback, the latter showing the first installation of the Strikfeldt design of hot-blast cupola, fitted with Steinmüller recuperators, and the former the latest type of the same design, similarly fitted. The groups rejoined in the afternoon at the Bergische Stahl-Industrie, Remscheid, and later dined as guests of the Company at Schloss Burg. This Company has a V.E.W. installation and also a Schack spiral recuperator cupola. The remaining visits were to plants of the Buderus group, the first at Staffel, the second at Wetzlar, having hot-blast furnaces of the Strikfeldt design yielding 2·5 and 25 tons/hr. respectively; and finally to the Lollar plant, which has a hot-blast cupola of the same design feeding what is probably the most advanced mechanised production track in the world, in this case for radiator sections. This plant created a great impression. At Weltzlar and neighbourhood, the parties were the guests for lunch and dinner of the Buderus Company.

After dinner on Friday, 14th May, Professor H. Jungbluth of Karlsruhe outlined to the first party the theoretical approach to the work of a new experimental station for the study of hot-blast cupola development now being established at the Wetzlar works of Buderus, to be operated in conjunction with Strikfeldt and Co. An engineer of this Company then showed plans of the station and the plant to be incorporated therein. On 21st May, the second party heard a similar statement from Professor Jungbluth, this time in English followed again by an account of the plant now being installed. These announcements were the first public statements to be made about this development. The latter gathering took the form of a dinner of welcome offered by the Verein Deutscher Giessereifachleute, the President of which, Herr W. Küster, was in the Chair, accompanied by the Vice-President, Director Paul Schiegries of Hilden, and the Chairman of Council, Dr. G. Schwietzke. Others present included Dr. F. Grabowski, Managing Director, and Dr. F. Grosser, Technical Director of the Buderus group, Professor Jungbluth, Dr. W. Patterson of the Technical Hochschule, Aachen, representing the German foundry trade association, Wirtschaftsverband-Giessereiindustrie, Director Otto Mattern, and Dipl.-Ing O. Hornung. Herr Küster welcomed the visitors on behalf of the Verein Duetscher Giessereifachleute and the Director suitably responded.

Both visits were completed throughout in accordance with the pre-arranged schedule and by general consent were considered, though arduous, to be highly successful. The warmest thanks of the Association and the visitors are due to M. Jacques Foulon of Brussels, Director of The Association Technique de Fonderie de Belgique, and to Herr W. Strikfeldt, of Gummersbach, for their great help in the arrangement of the Belgian and German visits, respectively.

International Flame Radiation Research

New Experimental Station at IJmuiden

The Flame Radiation Research Joint Committee has been carrying out experiments on the properties of luminous flames during the last few years. Following a discussion of some of the problems involved in this work, a description is given of the new experimental station which has been built for this international co-operative project in Holland.

ALTHOUGH the temperatures and radiating properties of non-luminous flames are well-known, as a result of a series of studies undertaken over a long period of time, the position is not so satisfactory in the case of luminous flames, i.e., those containing carbon particles in suspension. The radiating properties of the particles themselves are fairly well understood, but knowledge of the conditions governing their formation and disappearance still remains, to a large extent, in the empirical stage. It is, however, this very soot formation which governs the utilisation of a large number of gaseous and liquid fuels.

Just after World War II, technicians were agreed that, in spite of individual efforts, the problem remained unsolved, and that it could only be tackled on a really practical scale. The Conference on Modern Applications of Liquid Fuels, held in Birmingham in 1948, resulted in the first steps being taken towards an international approach to the question, and, in April, 1949, the International Flame Radiation Research Joint Committee came into being, with France, Great Britain and Holland as the participating countries. The Royal Netherlands Blast Furnaces and Steelworks (K.N.H.S.) had already gone as far as building an experimental furnace at IJmuiden, and the first joint trials took place in May, 1949. The encouragement received by the Committee from all directions has manifested itself in a practical way by an increase in membership, there being now three further participating committees—a United States Committee, a Battelle Memorial Institute Committee, and a Belgian Committee—and other national committees are about to be formed.

During the five years of the Joint Committee's existence, much valuable work has been carried out at IJmuiden, in both performance and combustion mechanism trials, and the results have been presented in a large number of reports, and are the subject of numerous scientific publications. The experimental furnace built by K.H.N.S. has been used for this work, and has given valuable service, but as it had, in the course of time, become worn, the Joint Committee decided to build a new one, as well as a special furnace for pulverised fuel firing. A site close to the Laboratories of the Royal Netherlands Blast Furnaces and Steelworks was chosen, and a new experimental station for flame radiation research has been built, which will house under one roof the two new furnaces, and give ample facilities with full instrumentation for work of wide scope to be undertaken.

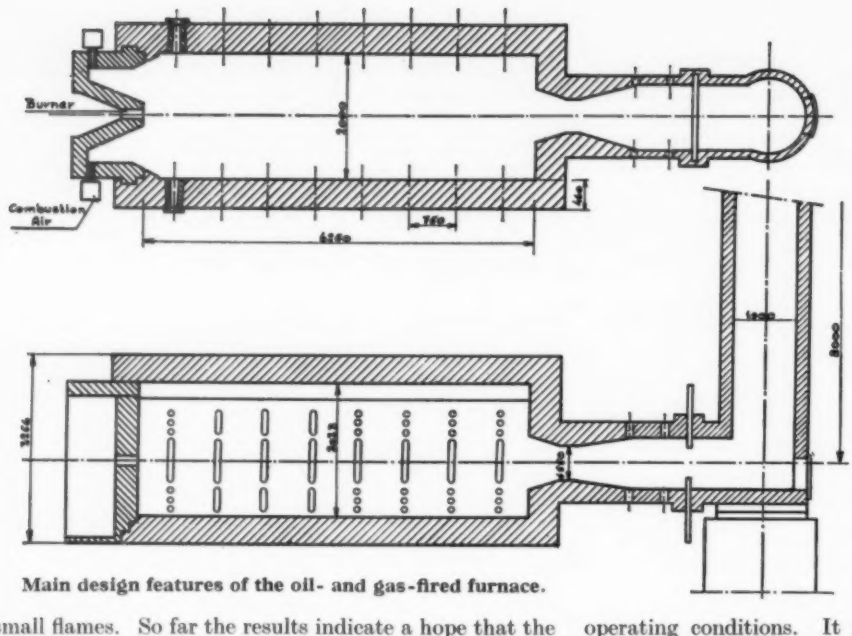
The inauguration of the new station took place on April 28th, 1954, in the presence of representatives of Belgium, France, Great Britain, Holland, Sweden and the U.S.A. Professor G. M. Ribaud, President of the Joint Committee, outlined the early development of the project, and Professor O. A. Saunders, Chairman of the Flame Radiation Research British Committee, discussed the reasons for large scale experiments, the applicability of the results to industrial furnaces, and the likely course of future work. The main points of Professor Saunders' address are set out below.

The Scale Effect

The processes which control the radiation from a flame are partly physical and partly chemical. The most important physical process is mixing of the fuel and air, which controls the rate at which fuel and oxygen molecules are brought together for combustion. However, the chemical processes of combustion are not usually simple, especially when there is more fuel than air present locally, and the production of carbon particles frequently occurs, giving rise to the so-called luminosity of flames, which is important in practice because of their radiating properties. In every furnace there is also the radiation from the molecules of carbon dioxide and water vapour to be taken into account, and in the particular case of pulverised coal flames there is the radiation from solid particles of coal or ash to be considered.

It is obvious that the whole picture is very complex. However, the fundamental parameters controlling the physical processes are well known, being in effect the Reynolds Numbers of the fuel and air streams, but less is known about the chemical parameters, except that the time of residence of the burning fuel in the flame is important. It is immediately obvious that a reduction in scale, even if accompanied by strict geometrical similarity of furnace and burner, necessitates an increase in velocity if the Reynolds Numbers are to be held constant, and that this requirement conflicts with maintaining the time of residence constant. In other words, in passing from a larger to a smaller flame, the requirements for keeping the physical and chemical effects in the same balance cannot be satisfied.

Even if this were possible, however, there would still remain the difficulty that radiation obeys an exponential law of variation with thickness of flame, which means that the bigger the flame the relatively more important the contribution of radiation from the outer parts than from the inner parts. In the extreme case, for example, of a large, highly-opaque flame, the radiation from the centre will be largely absorbed in the outer layers before it escapes. Unless, therefore, the index in the exponential law of variation of radiation with thickness, is constant and known, it is impossible to predict the radiation, or its variation with flame size. In the work of the Joint Committee, flames large enough for the results to be safely extrapolated to industrial conditions have been deliberately chosen, but at the same time work is being carried out in Sweden and elsewhere on



Main design features of the oil- and gas-fired furnace.

small flames. So far the results indicate a hope that the complicated problem of relating the performance of the two furnaces may be capable of solution. If so, this may prove an important step in the general research programme, since it may be possible to do more work in less time on the smaller furnaces. The effects of air preheating, which are very difficult to predict theoretically, must also be explored, and the future programme includes the installation of the necessary preheater as one of the most important items.

Applicability of Data

The question of the usefulness of the data obtained on the IJmuiden furnaces in other industries is best answered by saying that the study is of the flame rather than the furnace. "The flame" includes the methods of injection of the fuel and air and it is believed that in this broad sense the combustion conditions, and hence the radiating properties of the flames, are not greatly affected by the presence of the walls of the furnace, with the exception of the cold wall furnace, in which it is believed that the walls may affect the rate of combustion. This type of furnace, which is mainly the concern of the boiler industry, represents a rather special case to which attention is to be given. The possibility of extending the results to the wide variety of fuels used in practice is also a very important matter. The work which has already been done, shows that it may be possible to find the characteristics of fuels, such as their carbon/hydrogen ratio, which are important in determining their radiating properties. In one sense the fuel is the most flexible variable, and the use of additives to control radiation should not be overlooked. Unfortunately, it has already been found that the kind of fuel cannot be treated as a separate variable, but is probably linked with other variables. For example, in some trials in which liquid fuel was injected into a gas flame, under rapid mixing conditions fuel oil gave a higher radiation and emissivity in the early part of the flame than did creosote, whereas with slower mixing, creosote gave the higher emissivity and radiation.

It is most important that future work should produce results in the most fundamental form possible, so that they may be of the broadest application. For instance, although the overall radiation from a flame is being measured, a more fundamental property is the radiation emitted by a small volume, and it may well be that efforts should be made to express results in this way.

Future Trends

Of course a number of results in a more immediately usable practical form are bound to emerge during the performance trials. The trials have been labelled performance trials, because their main purpose is to find the overall performance of the furnace under different operating conditions. It may be found, for instance, that certain kinds of burners or fuels are apparently more suitable than others for certain conditions, and it may be safe to generalise these conclusions to the point where real improvements in practical furnaces can be obtained. One of the objects in starting with these trials was to use reliable and accurate instrumentation to find the kind of effects upon flame radiation which would occur when the main external variables were changed. It is for this reason that the Committee began by developing reliable instruments to measure the total radiation emitted by the flame at different points along its length, this being the flame property which is of most interest to the furnace designer, who is concerned with heating the charge of the walls of the furnace. The results of the performance trials, however, immediately throw up new problems in explaining them, and the experiments which have been called combustion mechanism trials are designed to this end. As the work progresses it seems, therefore, that there will have to be more and more combustion mechanism trials, which may well necessitate the development of new and more refined measurement techniques, such as the analysis of the soot particles in the flame. Another type of measurement which may become necessary is the examination of the radiation by spectroscopic means, since it is not known how far the assumption that the flames are grey is reliable in practice. The development of measuring techniques and instruments suitable for industrial furnaces has been an important feature of the work. For example, the gas analysis technique may well be useful to a wide range of industry, and the same applies to soot particle and other measurements.

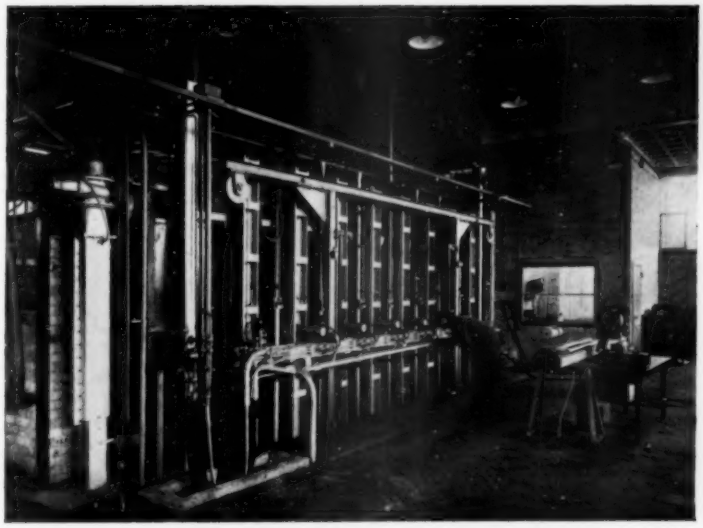
The practical gains in industry which may arise from the work are difficult to assess in figures. It is obvious that even 1% saving in fuels in industries which may be affected by flame radiation research would be well worth while. Such industries include iron and steel furnaces, coke ovens, gas works, brick and refractory furnaces, cement kilns, china and glass furnaces, and electricity generating plant. It is generally agreed that for the

lack of precisely the kind of data the project seeks to obtain, the design of furnaces has in the past been largely an art, and it is inconceivable that a more scientific approach would not lead to more immediate improvements. Beside the improvement in fuel consumption, there is the, perhaps, more important improvement in output and life of furnaces, which could be very significant indeed.

The New Station

Rectangular in plan, the new experimental station has its length in the north-south direction and, the two furnaces are placed side by side, with their burners ends towards the south. The southern part of the building is occupied by an instrument room, which gives a central and open view of the two furnaces, and by two auxiliary rooms for pumps, power distribution, stores, etc. On the north side, a specially equipped gas-analysis room has been constructed in order to separate the specialised equipment from the rest. Outside the building, on the southern side, are three liquid storage tanks for different kinds of fuel. The combustion-air preheater, and the coal preparation plant for the pulverised fuel trials will be situated on the east side: these two units will be erected in the course of the present year.

The experimental station is easily accessible by road, and has its own railway sidings. The total cost of the completed installation and its services, including all auxiliary equipment, such as the preheater, the coal preparation plant and the instrumentation, will amount to approximately £60,000.



The east wall of the oil- and gas-fired furnace.

Oil- and Gas-Fired Furnace

Combustion Chambers.

The inner cross section of the new furnace for oil and gas-firing (Furnace A) is 2 × 2m. and its length 6·3m.: it is thus about the same size as the old furnace. The construction of the side walls, through which the measurements must take place, had to be a compromise between what was required for thorough investigations (in effect, a wall consisting of holes and slots only), and what was considered to be necessary for a solid construction, with adequate insulation. It had been found, in the old furnace, that vertical slots allowing for a continuous assessment, in height, of the flame characteristics, were very valuable. In view of the discontinuous operation of the furnace, and the frequent temperature-level changes, it was considered unwise to make slots over the whole height of the furnace. Accordingly, in the design finally adopted, the four observing stations in the later part of the flame have only a central slot, with holes provided for the rest. The width of the slots and the diameter of the holes is 8 cm., and in order to make the construction of the whole wall a stable one, specially shaped bricks have been provided.

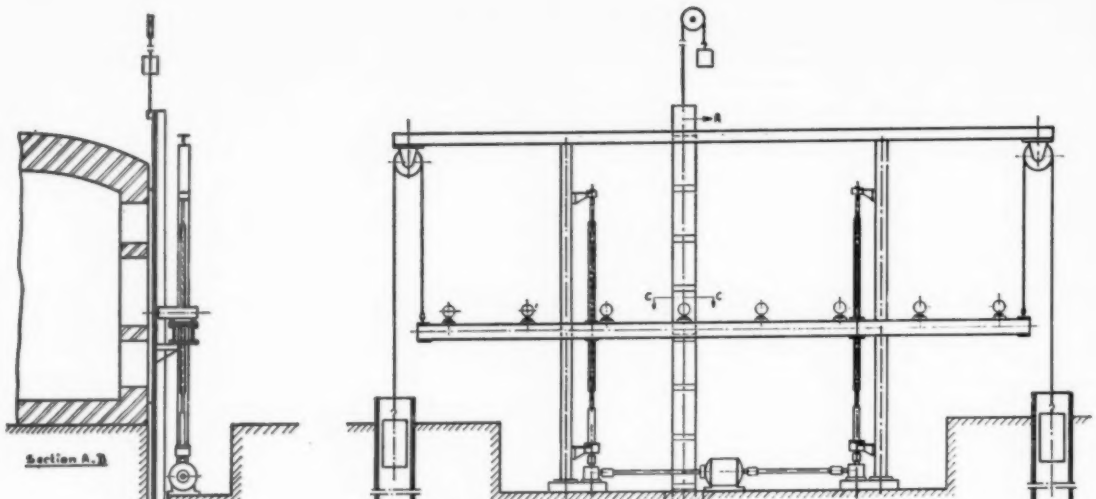
As it is desired to operate the furnace at wall temperatures of 1,600° C., it has been necessary to use a high-quality brick, which at the same time should show as little creep or growth as possible. For these reasons, sillimanite was chosen as the refractory material, and the complete wall is constructed of one brick (22 cm.) of sillimanite, a half-brick of porous sillimanite, acting as a high-quality insulating brick, and a half-brick of ordinary insulating brick. The specially shaped bricks are made of sillimanite.

Roof and bottom are of the same composite character as the walls, and the whole furnace, except the roof, is enclosed by a sheet steel casing. The old furnace was built on the ground, which meant that constant conditions could only be attained after a week, or longer. Because of this, the new furnace has been built clear of the ground, and rests on a set of beams. It may thus be possible to measure the heat losses through the floor.

The burner end of the furnace is constructed as a loose panel, in order to facilitate rapid changes in design. As in the old furnace, the burner is situated in a receding entry, the air for combustion being delivered by means of wind boxes giving a fairly even distribution of the air over the height. The exit end of the furnace is designed to provide a venturi-shaped waste-gas tunnel, with the idea of improving the mixing before the waste-gas samples are taken for temperature and gas composition measurements. The venturi may also be used to measure the waste-gas volume, and to provide a check on the waste-gas analyses. Furnace-pressure damper control is provided, which consists of two refractory plates sliding vertically in opposite directions. This arrangement was adopted to ensure that the flow from the venturi would not be affected by the use of asymmetrical dampers. The waste-gas tunnel gives access to a stack 8 metres high, designed so as to overcome friction loss in the venturi and waste-gas tunnel. The refractory material in the stack is high-quality fire-clay brick, backed up with ordinary-quality insulating brick.

Design of Doors and Openings.

Special consideration had to be given to the construction of the doors closing the openings, in view of the large number of slots and holes in the walls. In this connection it should be noted that work of a different character will be done through each of the side walls, the east wall being used for radiation measurements only, and the west wall being designed for the insertion



Arrangement of doors on east wall of oil- and gas-fired furnace.

in fixed and known positions of all the various kinds of probe.

Because of the good results which had been obtained by the simultaneous displacement, up and down, of the radiation pyrometers, this system has been adopted on the new furnace. The pyrometers, with their supplies of water, clean air and electricity, are mounted on a horizontal beam which can be raised and lowered by means of two long, mechanically-coupled screwed spindles. The vertical water-cooled doors have been made to slide along a pair of water-cooled tubes, one on each side of a slot. These doors, which are about twice the furnace height in length, are counter-balanced, and thus can easily be moved up and down by means of an interlocking pin on the horizontal beam. In this way the holes in the doors are always in line with the radiation pyrometers on the beam, and at the same time reasonable air-tightness is secured.

On the west wall, fixed doors have been provided to cover the slots. These doors have eight square holes with flaps, which can be used for introducing water-cooled probes. On the outside of the furnace, there are a number of vertical pipes with sliding grips, which can be used to fix in position probes or any other instruments (e.g., a black body furnace).

Supply and Control of Input Variables.

In order to get maximum results from the measurements taken on the flames, it is important that all input variables should be in complete control, and automatic equipment has been installed so that full attention can be devoted to the actual measurements. Oil can be taken from any of the three tanks and is heated to the required temperature before pumping to the furnace. Two pumps are provided, one for quantities above 50 kg/hr., and an adjustable diesel-engine fuel pump for the small quantities used for carburetting gas flames. Larger quantities are measured by means of an orifice, specially designed for viscous liquids and working on a recording controller.

Steam (after being superheated in a small gas-fired unit), compressed air, coke-oven gas and oxygen can be taken from the works mains, measured by orifices and controlled to give a constant flow. If required, propane can be taken from a railway tank car, reduced in pressure, and delivered to the furnace after being measured. The combustion air is delivered by fans, and when the preheater has been installed it will be possible to supply air at any temperature up to 750° C. Furnace pressure, although not an input variable in the strict sense, is measured and controlled by an hydraulic controller, operating on the two damper halves, which counterbalance each other. Water, both pure and from the mains, is available for use with instruments and for cooling purposes. The measuring and controlling instruments for the input variables are mounted on one wall of the instrument panel. The average load of the furnace is roughly $2{\cdot}5 \times 10^6$ k.cal./hr., i.e., 250 kg. of oil or 600 cubic metres of coke oven gas per hour.

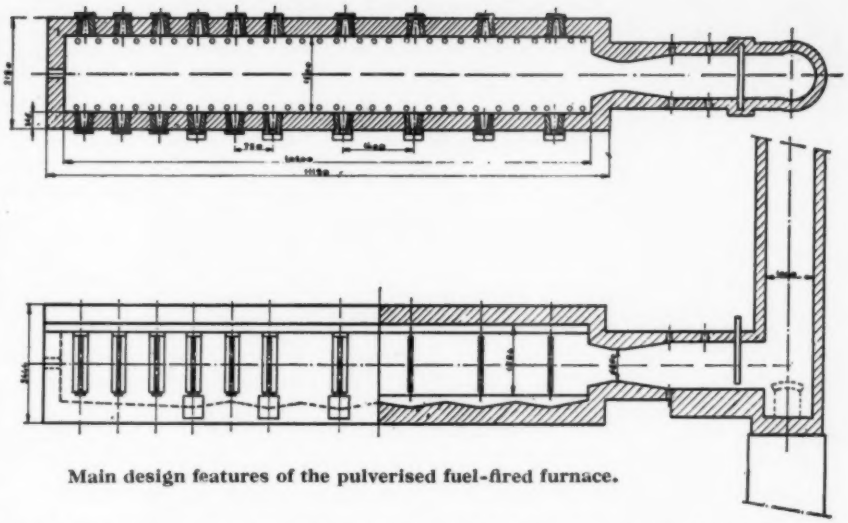
Pulverised Fuel-Fired Furnace

The Furnace.

Although no more than the foundations are completed for Furnace B, which is designed for pulverised fuel firing, a short description of the plan of construction may be useful to complete the picture of the new experimental station as a whole. This furnace has been designed along the same lines as the oil and gas furnace, although it has a smaller cross-section ($1{\cdot}5 \times 1{\cdot}5$ m.) and is much longer (10 m.), the ratio of length to cross section being about 7 : 1, as compared with 3·5 : 1 for Furnace A. The furnace will be constructed with a wall thickness of $1\frac{1}{2}$ bricks, made up of one brick (22 cm.) of

high-quality insulation (hot-face), with a special coating against ash attack, and backed up with a half brick of ordinary quality insulation. It will be equipped with the same arrangement of slots, doors and moving beam, etc.

The floor will be inclined towards one side and small doors will be provided on this side in order to facilitate ash removal. As the quantity and location of the ash deposits in the furnace and stack are at present unknown, and also the way in which difficulties with loose or solidified ash will present themselves, the furnace design has been made flexible, so as to enable these problems to be dealt with as they arise. Some practical experience with the fuels to be used is necessary before a final design can be adopted.



Main design features of the pulverised fuel-fired furnace.

The average load of the furnace will be of the order of 250 kg. coal per hour ; by means of water-cooled pipes to be introduced through holes in the roof, the thermal load of the furnace can easily be varied between 20 and 70%. It is also planned to equip this furnace with oil-burning facilities, in order to be able to compare the different types of fuel under exactly the same conditions.

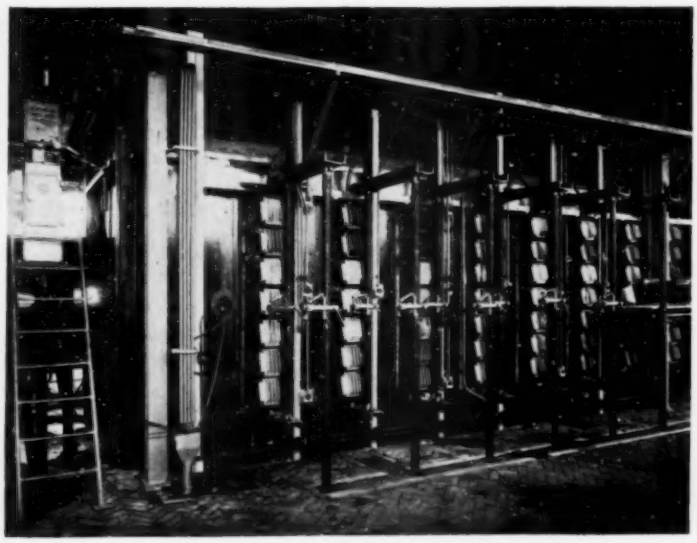
Coal Preparation Plant.

The purpose of the coal preparation plant is to provide the furnace with dry pulverised fuel of widely different characteristics. It must, therefore, have maximum flexibility, and the separate operations of crushing, drying, milling and weighing are interconnected through storage hoppers. The maximum capacity of the plant will be 500 kg./hr. The coal, having been crushed to −3 mm., will be dried in a pneumatic dryer and then pulverised to 90%–200 mesh in a ball mill, and stored in a 2-ton hopper, whence it will be weighed and deposited at a constant rate into the primary air duct. It is planned to burn coals ranging from anthracite to lignite (or brown coal) and with from 8–30% ash content. It is hoped that this coal preparation plant will be ready for operation in December, 1954.

Air Preheater.

The availability of an air preheater is an essential requirement for work with pulverised fuel. It was decided to provide an installation which would also be capable of supplying preheated air to the oil- and gas-fired furnace, so as to enable results to be compared with those obtained with cold air. The use of the waste heat from the furnace was considered as a means of obtaining the preheat, but this idea was abandoned in view of the difficulties to be overcome : e.g., in order to avoid having to install two preheaters it would have been necessary to use a common stack for two furnaces. Also, in view of the widely-varying and frequent changes in load level of the furnaces during trials and of the wide range of preheat needed, a somewhat complicated system of control (including by-passes) would have been necessary. Furthermore, the danger of upsetting the furnace pressure control, which is of such primary importance, would always have been present. For these reasons, the Joint Committee decided to build a separately-fired preheater which will be fired by blast furnace gas (maximum 1,600 cu. m./hr.). The heater will be constructed of smooth alloy steel tubes (Schack Patent) which are suspended vertically.

The preheated air will pass through a refractory-lined tube to both furnaces ; the instruments for measurement and control of this preheater will be mounted together with those for the input variables of the pulverised fuel furnace on a separate instrument panel opposite that for Furnace



The west wall of the oil- and gas-fired furnace.

Gas analysis facilities housed near furnace stack.

A. It is hoped that the preheater will be ready in July of this year, so as to enable trials with preheated air on the oil- and gas-fired furnace to be started in August or September.

General Facilities

The general facilities can be divided into a number of groups, each covering a certain class of work. The first group consists of six electronic recorders and one indicator, which are of a universal type with interchangeable ranges and chart speeds. Some are line recorders, others multi-point recorders. They record all the electrical outputs obtained from the furnaces, i.e., radiation and suction pyrometers, thermocouples placed in walls and roof, heat flow meters, etc. All leads from both furnaces end in a panel from which any recorder can be connected by means of flexible leads with any measuring source.

The second group of facilities —those for gas analysis —are housed in a separate room near the furnace stacks. The equipment in this small laboratory is similar to that of a normal gas-analysis laboratory, with the addition of two CO_2 recorders, which allow rapid surveys of flow patterns in the furnace to be made, or which can be used for recording the CO_2 content of the waste gases. There is also a modified Bone & Wheeler gas analysis apparatus for accurate determination of gas components : special provision is made for the sampling and analysis of carbon soot in the flame. Both instrument room and the gas-analysis room are kept under a slight air pressure, to minimise dust penetration.

The third group consists of instruments set up in a room in the Central Laboratories. These comprise two black-body radiation furnaces (with potentiometers for calibration of radiation pyrometers) thermocouples and heat flow meters, and further equipment for the analysis of gas and carbon soot samples (including an analytical balance).

Finally, it should be mentioned that the small water-cooled furnace, which has been in operation for several years in the Research Laboratories of the Royal Dutch Shell Company at Delft, has been transferred recently to this new station. This furnace is a geometrically correct model of the oil- and gas-fired furnace, and has been and will continue to be used for testing scale effects on flame radiation under conditions which can be changed more widely and rapidly than is possible with a full-size furnace. This model will be erected in a few weeks in the pump room, and will make use of all the facilities for control and experimenting which are already available.

Conclusion

It will be seen from the foregoing that the new experimental station will provide every possible facility for carrying out a wide range of experiments on all kinds of flame. Oil, gas, propane, pitch, coal, etc., can be used as fuel ; combustion air with a preheat up to 750° C. and eventually enriched with oxygen is available ; and steam, compressed-air or oxygen can be used in any burner. All the primary variables are controlled as to pressure, temperature, flow, or other important properties. A range of universal recording instruments is available for measurement of temperature and radiation, and a specially equipped gas analysis room serves the need for both many and accurate analyses. Two furnaces, well-insulated and able to withstand temperatures of, respectively 1,600° C. and 1,500° C., have been specially designed for the investigation of different kinds of flame. All this equipment is housed in a building which provides ample space for experiments and where working conditions are the best that can be achieved.

British Watch Springs

Samuel Fox & Company of Stocksbridge, near Sheffield, associated with The United Steel Companies, Limited, is a works with tradition and a history, but one which has kept up with the times. Because of war-time difficulties Fox's were asked to provide items for which their steel was suitable, such as A.A. fuse springs and aircraft clock springs : until then this business had been almost exclusively Swiss.

The experience gained stood them in good stead when, in 1948, they accepted a challenge from their customers to produce watch springs. Special machine tools were installed and several years of experiments followed, during which they received helpful advice and collaboration from their customers. This has been of tremendous value in helping them to establish the 100% British watch spring, which they regard as a substantial contribution to the nation's economy, and an indispensable asset in a time of emergency.

By 1953, Fox's were in commercial production on a 13-ligne wrist-watch spring, and, in addition established the fact that British steel could make springs for telephone dial mechanisms, for which the General Post Office had previously specified Swedish steel. At the moment, they are selling about 30,000 carbon steel clock and watch springs to British manufacturers each week and development work is proceeding to establish production techniques in order to make springs from special alloys and stainless steel.

The Non-Ferrous Metal Industry in India
Symposium at Jamshedpur

INDIA'S non-ferrous metal industry is still in its infancy, although there are known to exist in the country considerable reserves of non-ferrous metal-bearing minerals awaiting exploitation and development to feed the expanding Indian engineering and metal industries. With the object of focusing attention on the present state of the industry, and of discussing ways and means of stimulating its growth to meet present and future requirements, a Symposium on the Non-Ferrous Metal Industry in India was held at the beginning of February, under the auspices of the National Metallurgical Laboratory of India, at Jamshedpur.

Thirty-six technical papers, from Indian and overseas sources, were presented and discussed during the three-day meeting. Those participating included representatives of industrial organisations, Government and educational institutions, Council of Scientific and Industrial Research staff of sister National Research Laboratories, and a number of overseas delegates, including Dr. N. P. Allen, Superintendent of the Metallurgy Division of the National Physical Laboratory, Teddington. On the opening day, Dr. Allen gave an interesting and informative lecture on "Titanium and Zirconium," wherein he discussed at length Indian resources of these metals in the general context of world reserves, and their physical characteristics in relation to their multifarious applications, and indicated the trends in researches under way in the United Kingdom on these two metals and their alloys.

On the evening of the first day, Mr. E. H. Bucknall, Director of the National Metallurgical Laboratory, spoke on "High Temperature Materials," discussing at length the phenomenon of creep and referring to his investigations at the National Physical Laboratory (U.K.) on age-hardening alloys with improved creep resistance. Mr. Bucknall also discussed the requirements of high temperature materials for use in the various parts of the gas turbine—combustion chambers, turbine discs, stator and rotor blades, etc.

The symposium was inaugurated by Mr. J. G. Berry, Works Manager, Indian Copper Corporation, Ltd., Ghatsila. Mr. Bucknall then reviewed the scope of the symposium, outlining the overall position regarding Indian non-ferrous metal wealth, and indicating possible lines of expansion in different fields. Some of the points raised in the papers presented for discussion are referred to below.

General Surveys

The Non-Ferrous Mineral Wealth of India. By P. K. CHATTERJEE (Geological Survey of India).

A Survey of the Non-Ferrous Metal Industry of India. By E. H. BUCKNALL and R. B. NIJHAWAN (National Metallurgical Laboratory).

Indian Standard Non-Ferrous Metals and Alloys. By E. H. BUCKNALL and S. C. DE (National Metallurgical Laboratory and Metallurgical Inspectorate, Tatanagar).

Mr. Chatterjee's paper took the form of a brief survey of the nature, location, output and reserves of deposits of important ores of manganese, magnesium, titanium, aluminium, lead, zinc, copper, gold, silver, tin, tungsten, cobalt, nickel, mercury and vanadium, for the production of industrially useful non-ferrous metals. Figures for the amounts available were given, and the sufficiency or inadequacy of the deposit was indicated in each case.

In surveying the non-ferrous mineral production and reserves of India, Mr. Bucknall and Dr. Nijhawan emphasised the present deficiencies and surplus capacities in the general context of indigenious requirements and exports overseas. Attention was drawn to the possibilities of substituting available indigenous materials for those in short supply, and of making the most of metals of which resources were abundant. The general policy, outlined in the Five Year Plan, of putting home use before export, and of exporting semi-manufactured or fully-manufactured products rather than untreated ores, was endorsed. Each of the important metalliferous minerals was dealt with in turn in respect of reserves, production and the existing non-ferrous industry, or that which could readily be established. Specific lines along which advances were most probable were indicated for aluminium, copper, lead and zinc.

The need for metallurgical specifications was discussed by Mr. Bucknall and Mr. De, with special reference to Indian conditions. After considering the general principles of the drafting and interpretation of metallurgical specifications, they dealt with the 33 standard specifications for non-ferrous metals and alloys so far issued by the Indian Standards Institution, together with the Indian specifications relating to non-ferrous metal and alloy products. The authors also considered the requirements for and possible lines of additional specifications.

Aluminium

The Aluminium Industry in India. By D. P. ANTIA (Aluminium Hindusthan, Ltd., Calcutta).

The Structural Aluminium Industry. By S. K. GHASWALA (Chartered Engineer, Bombay).

Extraction and Refining of Aluminium. By M. C. DUBE (The Aluminium Corporation of India Ltd., Jaykaynagar).

Preparation of Aluminium-Silicon Alloys by Alumino-Thermic Reduction. By R. M. KRISHNAN, M. N. KHANNA, A. B. CHATTERJEA and B. R. NIJHAWAN (National Metallurgical Laboratory).

In spite of large deposits of good grade bauxite and potential power sources, the price of aluminium in India is the highest in the world and Dr. Antia attributed this fact to the small overall production. In view of the scarcity of copper, lead, zinc, tin, nickel, etc., the replacement of these metals by aluminium was stressed, and in describing numerous applications of the light alloys the advantages which could result from their use were indicated.

Potential uses of aluminium alloys in civil engineering structures were brought out by Mr. Ghaswala who gave a brief description of the general development trends in the aluminium industry, pictured against a background of world production, price structure and the production potentials of some European countries. Analyses of *per capita* production were made for different countries of the world (including India), for aluminium alloys, iron and steel, and electrical energy.

The techniques used in the extraction and refining of aluminium in India were described by Mr. Dube, who opened with a reference to the important sources of bauxite in the country. Digestion tests of Bihar bauxite and the Bayer process were discussed, and the consumption of raw materials for the production of alumina and aluminium shown. Various theories concerning the electrolytic reactions were considered, whilst on the practical side the advantages and disadvantages of various types of furnace were set out, and the binding property of pitch and the types of electrode discussed. Finally, Mr. Dube dealt with the refining of aluminium metal and presented practical operating data.

The paper from the National Metallurgical Laboratory detailed the results of researches on the preparation of aluminium-silicon alloys by the alumino-thermic reduction of quartz. The reduction was observed to depend mainly on the particle size of the quartz; the amount of cryolite in the charge; the temperature of the reactants; and the holding time. The physical properties of the alloys made in this way were found to be as good as those produced by direct alloying; and the authors, after considering the general economics of the process, concluded that it could usefully be exploited for commercial applications in countries dependent on silicon imports and rich in bauxite and quartz.

Manganese

The Indian Manganese Ore Industry and the Scope for its Development. By B. R. NIJHAWAN (National Metallurgical Laboratory).

Recent Researches on the Dressing of Low-Grade Manganese Ores in India. By P. I. A. NARAYANAN (National Metallurgical Laboratory).

The Present Position and Future of the Manganese Industry, with Special Reference to Indian Resources. By E. A. G. LIDDIARD and A. H. SULLY (Fulmer Research Institute, England).

High Purity Electrolytic Manganese for Low-Grade Ores as a Substitute for Various Forms of Manganese now being used in Metallurgical Industries. By B. C. KAR (National Metallurgical Laboratory).

Dr. Nijhawan, in reviewing the reserves of manganese ores in India, indicated the various ways of utilising them and advocated their export after conversion to ferro-manganese rather than as raw unprocessed ores. Reference was made to the up-grading of low-grade manganese ores by mineral dressing methods, and to the possibilities of their thermal beneficiation for the production of ferro-manganese. Recent research work on these lines carried out at the N.M.L. was discussed, and reference was made to the efforts of countries deficient in manganese ores to tap all possible sources of manganese, such as recovery from steel slags, manganiferous iron ores, etc.

A case for the conservation of the mineral wealth of India, by banning selective mining, was made out by Mr. Narayanan, who emphasised the necessity of beneficiating low-grade manganese ores. Exhaustive beneficiation tests on several ores of different types showed that enrichment to about 48% Mn could be obtained with good recovery. Garnet could be removed by electrostatic separation, and fundamental studies on the floatability of manganese mineral and garnet were being made to investigate the feasibility of a flotation method of concentration.

Statistics quoted by Mr. Liddiard and Dr. Sully showed that manganese ore production was directly related to world steel production, but fluctuations in steel output affected Indian ore production much more than production from any other source. A steady and increased demand for manganese was likely to result from research and development on :

(1) Improvement of the quality of the end product, and concentration of the manganese metal content to reduce freight charges.
(2) The technical advantages of manganese as an alloying constituent in steel, and the replacement by it of the more expensive alloying additions.
(3) The use of manganese in non-ferrous alloys, with particular reference to alloying constituents which increased the stability of the ductile *gamma* phase of manganese.
(4) Manganese as a coating to provide corrosion and abrasion resistance to steel and non-ferrous metals, particularly in those fields in which zinc and nickel were at present used.

In conclusion the authors advocated the formation of a research and development association to promote the use of manganese.

According to Dr. Kar, India produced about a million tons of high-grade manganese ore a year, and about the same quantity of low-grade ore was dumped in the mining area. Under the Five Year Plan, efforts had been made to utilise the abundant low grade ore by beneficiation and by the production of electrolytic manganese. Dr. Kar discussed the use of high-purity electrolytic manganese, made from low-grade ore, in place of the different forms of manganese, especially ferro-manganese, now used in the metallurgical industries. The main disadvantage was the high cost of production, but a substantial reduction could be expected if demand increased.

Copper

The Copper Smelter at Ghatsila. By R. N. KHARE (Indian Copper Corporation, Ltd., Ghatsila).

Removal of Aluminium from Copper-Based Alloys to Ensure Pressure-Tight Castings. By A. T. PAL (Annapurna Metal Works, Calcutta).

The Contradicting Aspects of Certain Factors Affecting the Quality of a Brass Ingot for Working. By M. M. RAY (Indian Copper Corporation, Ltd., Ghatsila).

The smelter at the Ghatsila works of the Indian Copper Corporation, whose layout and operation was described by Mr. Khare, treats froth-floated chalcopyrite concentrate, containing 24–26% copper, to produce a matte containing 40–42% copper. The convertion of the matte to blister copper in convertors was described and details were given of the refining practice at Ghatsila.

In a further paper on copper alloys, Mr. Pal, drew attention to the harmful effect of even traces of aluminium in pressure-tight gun-metal castings, because of the resultant leakage. Aluminium was sometimes introduced into the alloy along with metal scrap, such as naval parts, impellers, etc. It had been shown that passing dry compressed air (at 100 lb./sq. in. pressure) through melts containing different proportions of intentionally-added aluminium caused the removal of even traces of aluminium by preferential oxidation, with practically no loss of zinc or tin. The extent of its removal was dependent on the aluminium content of the melt and the amount of compressed air passed through it.

The practical difficulties in the way of attaining a sound brass ingot suitable for working were outlined by Mr. Ray, who discussed the influence of casting

temperature on the entrapment of gases and dross, surface condition of the ingot, crystallisation, primary pipe, and the presence of dissolved gases. The effect on the quality of the ingot of rate of pouring and mould dressings was considered, and the importance of factors like the rate of cooling and the extent of the pasty range stressed.

Chromium and Nickel

Chromium—An Appreciation. By E. H. Bucknall (National Metallurgical Laboratory).

Valves in High Nickel Alloys. By A. T. Pal (Arnapurna Metal Works, Calcutta).

A review of the present position and the trends of metallurgical industry indicated that the considerable expansion of chromium consumption on a world scale was a virtual certainty, the position being especially clear as regards stainless steel production. Although there were no prospects of engineering applications of chromium-rich alloys, the expansion of production of non-ferrous materials containing considerable amounts of chromium could also be confidently predicted. Mr. Bucknall believed that the increased demand could be met by moderately pure grades of ferro-chrome, plus an increased amount of chromium metal, assuming that cheaper methods of production could be found. Indian reserves of chromite were considerable, and could be profitably exploited if converted into metallurgical products. They could be used for the development of an Indian stainless steel industry, as well as for export. Indian research had indicated a process whereby a serviceable, but possibly not exportable, grade of low-carbon silicon-containing ferro-chrome could be made by reducing chromite, which might be low-grade, in the electric furnace, along with ferro-silicon and aluminium.

The practical difficulties encountered in the manufacture of high nickel alloy valves were enumerated by Mr. Pal, who gave details of the properties of the core sand, facing sand and backing sand used for moulding. Suitable fluxes were discussed, but the author said that, despite all the precautions taken, porosity had not been entirely eliminated.

Reference to the welding of Monel and K-Monel was made by Mr. F. A. Ball (see " Welding ").

Other Metals

Thermodynamic Aspects of Chemical Reactions as Applied to the Smelting and Refining of Lead. By A. B. Chatterjea and B. R. Nijhawan (National Metallurgical Laboratory).

Tantalum and Niobium Minerals in India. By N. R. Srinivasan (Indian Institute of Science, Bangalore).

Beryllium, Lithium, Magnesium and their Alloys, with Reference to the Possibility of their Manufacture in India. By K. K. Dar (Atomic Energy Commission).

Refining of Non-Ferrous Metals. By J. G. Berry (Indian Copper Corporation, Ltd., Ghatsila).

Chemical Treatment of Molten Non-Ferrous Metals. By F. C. Goldsmith (Foundry Services, Ltd., Birmingham and Greaves Cotton & Co., Ltd., Calcutta).

Dr. Chatterjea and Dr. Nijhawan brought together the available data on the thermodynamics of the reactions involved in the extraction and refining of lead. Equilibrium constants were calculated from the standard free energy data to explain the desideratum of optimum working conditions required during roasting, smelting and refining. Graphs showing the changes with temperature of standard free energies of formation of oxides, sulphides, chlorides, fluorides, sulphates, carbonates and silicates were incorporated in the paper for ready reference.

The paper by Dr. Srinivasan presented a critical review of recent literature concerning tantalum and niobium, two rare metals which had received considerable attention in view of their importance. The review covered such aspects as the discovery of new minerals ; exploration for and production of minerals in various parts of the world ; and studies of the pure metals and their alloys and compounds. Recent work on the possibilities with regard to these metals in India was emphasised by Dr. Srinivasan.

The Indian sources of the raw materials for the production of beryllium, lithium and magnesium were reviewed by Mr. Dar, along with the applications of these metals in world peacetime and wartime industries. While Indian magnesite reserves were good, and those of beryl fairly good, the position with regard to the reserves of lithium minerals was not so good, but might improve with future investigations. The main metallurgical aspects were correlated with the new hydro-electrical developments.

The fundamentals of the refining of non-ferrous metals were discussed by Mr. Berry, who gave examples of removal of impurities by electrolysis, distillation, volatilisation, etc. The refining of copper, lead, zinc, tin and some other metals was described and the author stressed the importance of economics and the time factor in refining processes.

Mr. Goldsmith discussed the various means available for the removal of undesirable impurities from molten non-ferrous metals and alloys, including the use of fluxes ; oxidation for the removal of hydrogen ; and de-oxidation of some alloys by phosphorus, copper, magnesium, magnesium-boron, etc. Fluxes for the elimination of lead oxide and the elimination of alumina by different fluxing techniques were considered, and details given of the use of magnesium chloride flux for aluminium-magnesium alloys and the degassing by chlorine through the introduction of hexachloroethane. Reference was also made to the use of boron and titanium for the purpose of grain refinement.

Refractories

Recent Trends in Refractory Practice in the Non-Ferrous Metal Industry. Bhaskar Rao and Rabindar Singh (National Metallurgical Laboratory).

Graphite Crucibles. By K. K. Majumdar (Indian School of Mines and Applied Geology, Dhanbad).

In a review of recent developments in the field of refractories applicable in the non-ferrous industry, the authors set out the requirements of refractories employed for smelting copper, aluminium, zinc and lead, and discussed the advantages gained by the use of the newer refractories. Reference was also made to development work being undertaken at N.M.L. to meet the requirements for special refractories.

During World War II, a graphite crucible industry was started in India and in his paper Mr. Majumdar described the manufacturing techniques employed. The chief ingredients were graphite and clay, and determinations of the burning rate of Indian graphite showed it to be slightly inferior to Madagascar and Ceylon graphites.

Welding

The Welding of Non-Ferrous Metals. By R. Ghosh (Indian Oxygen and Acetylene Co., Ltd., Calcutta).

The Welding of Non-Ferrous Metals by the Argonarc and Argonaut Processes. By J. A. Muliyal (Indian Oxygen and Acetylene Co., Ltd., Calcutta).

The Welding of Monel and K-Monel. By F. A. Ball (The Mond Nickel Co., Ltd., London).

The first two papers dealt generally with the subjects detailed in their titles, and although Mr. Ghosh referred to electric welding processes, he was mainly concerned with the oxy-acetylene process.

Although Monel and its heat-treatable modification K-Monel could be welded of all normal techniques, Mr. Ball discussed the advantages and limitations of fusion, resistance and pressure welding for various types of fabrication. The causes of and cures for various welding defects were described and the procedure for avoiding corrosion, particularly of the cavity type, in fabricated structures was outlined. A number of specific examples of defective welds in Monel and K-Monel were presented and a detailed explanation of each was advanced.

Hollow-ware

Utensils—A Major Non-Ferrous Industry of India. By E. H. Bucknall and M. S. Mitra (National Metallurgical Laboratory).

Aluminium and brass domestic utensils are major products of the Indian non-ferrous metals industry, and Mr. Bucknall and Dr. Mitra pointed out that they accounted for 80% of the total consumption of these metals, the utensil industry being a much more significant part of the non-ferrous industry than elsewhere in the world. Of the annual production of 40,000 tons of brass utensils, not more than 7,000 tons were produced in registered factories, the rest being manufactured by the cottage industries. Aluminium utensils, on the other hand, were mostly factory made, the annual production being estimated at 12,000 tons. India was an exporter of utensils, mainly to East Africa, the Middle East and South Asia.

Production of aluminium and copper in India was insufficient to meet the needs of the utensil industry and aluminium was the only non-ferrous metal whose production could readily be increased appreciably in India. Steps were being taken on these lines in the Five Year Plan. From the point of view of national economics, aluminium should replace copper for utensil manufacture, in so far as it could be done without prejudice to the indigenous manufacture of copper. Conservatism and antipathy of consumers would have to be overcome, and suitable publicity might be a necessary accompaniment to improved design and manufacture.

Non-Ferrous Coatings on Steel

A Comparative Study of Non-Ferrous Coatings on Steel. By A. N. Kapoor, A. B. Chatterjea and B. J. Nijhawan (National Metallurgical Laboratory).

Electrodeposition of Tin-Zinc Alloy as a Protective Coating on Ferrous Metals. S. K. Ray (Central Electrochemical Research Institute, Karaikudi).

Bearing in mind the availability of raw materials in India, and the importing of large tonnages of tin and zinc for coating steel, the authors of the first paper discussed the possibilities of using aluminium as a coating metal. A comparison of the micro-structures obtained by different hot dip processes and of the resistance of the coated product to corrosion were presented, and points in favour of aluminium-coated steel indicated.

Mr. Ray stated that electrodeposition of an alloy of tin and zinc gave better protection than electrodeposited zinc, cadmium or tin, a 0·0003 in. layer of 75–80% tin content being the best of the purpose. Experiments were described for plating from a non-cyanide solution, a bath consisting of a mixture of sodium stannate, sodium zincate and an excess of caustic soda being used.

Powder Metallurgy

Powder Metallurgy Applications of Non-Ferrous Metals. By S. Ranganathan and B. R. Nijhawan (National Metallurgical Laboratory).

Characteristics of Metal-Graphite Brushes Made by the Powder Metallurgy Technique. By G. D. Joglekar and Daneswar Sen (National Physical Laboratory, New Delhi).

After dealing with the theoretical principles and practical results of sintering both homogeneous and heterogeneous powders, Mr. Ranganathan and Dr. Nijhawan discussed at length the application of powder metallurgical techniques to non-ferrous metals and alloys. Recent notable developments in powder metallurgy, in the field of heat-resistant metallic compositions essentially of non-ferrous composition, were described along with developments utilising the modern liquid disintegrator method for making metals and alloys into powder, and the infiltration technique. Reference was made to cermets and the latest carbide compositions, and the paper concluded with a discussion of the possibilities of applying powder metallurgical techniques in the Indian non-ferrous metals industries.

The authors of the paper on metal graphite brushes dealt briefly with the process of manufacture before discussing their electrical and mechanical characteristics under different conditions of operation. These characteristics were often conflicting in nature, and a proper selection of the brush grade was necessary to ensure optimum working conditions.

Miscellaneous

Creep Resistant Non-Ferrous Metals. By A. A. Krishnan and Ved Prakash (National Metallurgical Laboratory).

The authors described briefly creep phenomena and discussed the various factors influencing creep properties, such as grain size, alloy additions, dispersed phases, cold work and heat treatment. A review of the newer non-ferrous alloys based on aluminium, magnesium, copper, nickel, chromium or cobalt was presented in some detail, and brief reference was made to the titanium-base and beryllium-base alloys. The need to develop the latter alloys was stressed in view of their industrial and strategic importance.

Vacuum—A New Tool in Extractive Metallurgy. By P. P. Bhatnagar and T. Banerjee (National Metallurgical Laboratory).

Following a discussion of the theoretical considerations involved in metal extraction under vacuum, the general advantages of carrying out reactions in this way were stated to be the lower temperature for reaction and the possibility of carrying reactions to completion by removal of one of the reaction products. The conditions for the reduction and dissociation of oxides, sulphides, halides, hydrides, and nitrides, were discussed, and examples cited of reactions of this type adopted for metal-winning.

Lattice Diffusion in Face-Centred Cubic Metals. By S. S. Bhatnagar, D. D. Kaushal and B. R. Nijhawan (National Metallurgical Laboratory).

In surveying the available information on lattice diffusion between two face-centred cubic metals, the authors described the Grube and Motana method of determining diffusion constants. Various possible mechanisms of diffusion were outlined, and the preference

for the vacancy mechanism in the face-centred cubic metals, as judged from theoretically calculated values for activation energies, was discussed. The Kirkendal effect, and the Darken equations taking account of this effect, were stated, and mention was made of the Onsager equations for irreversible processes and their application to diffusion. Reference was also made to metallurgical processes involving diffusion.

Complexing of Metallic Ions with Organic Acids and their Application to Analytical Problems. By M. R. VERMA (National Physical Laboratory, New Delhi).

This paper described methods of complexing and estimating the metallic ions in solutions containing copper and arsenic or antimony.

Some Studies of Recovery and Oxidation Characteristics of Copper by Thermo-Electric Phenomena. By J. MUKHERJEE and G. P. CHATTERJEE (Bengal Engineering College, Howrah).

Although the changes in thermo-electric properties of a metal or alloy due to physical changes had been studied, little work had previously been carried out, using thermo-electric phenomena, to study minute changes not appreciably affecting the microstructure or mechanical properties. The authors showed that changes in the thermo-electric properties could be used for the purpose of studying such minute changes, whether on the surface or within the body of the metal.

Technical Films

Technical films on "Atomic Energy" "Welding of K-Monel," "Magnesium Metal from the Sea," and "Living Silver" were shown in the evenings, and on one evening a dinner was held at the Beldih Club in conjunction with the Indian Institute of Metals. The afternoon of the last day was devoted to a tour of the National Metallurgical Laboratory.

In his concluding remarks, Mr. Bucknall, Director of N.M.L., thanked those participating in the meeting, and expressed the hope that it would serve to develop industry in many useful ways. He also thanked the organisers of the Symposium—Dr. B. R. Nijhawan, Deputy Director, N.M.L. and Dr. A. B. Chatterjea, Senior Scientific Officer—for having brought it to a successful conclusion.

Europe's Biggest Cemented Carbides Factory

EUROPE'S latest, and one of the world's largest factories for making cemented tungsten-carbides has recently been put into operation in Sweden by the well-known Sandvik Steel Works. The factory is intended entirely for the production of Coromant, introduced in 1942 and now extensively used for cutting tools in the engineering industry and as rock-drill bits. Though no production figures have been released, it is claimed that the capacity considerably exceeds the company's previous output of some 90 tons per annum.

The new plant, which has cost about Kr.15,000,000 (£1,000,000) and employs 300, is situated in the southern outskirts of Stockholm, to which the company has transferred most of the staff and equipment from the former premises at the Lumpalampan Bulb Factories, the Co-operative Union subsidiary with which collaboration was originally started in this field. Since 1947, however, the production of Coromant has been carried on entirely under the aegis of the Sandvik Works.

A fine specimen of modern Swedish industrial architecture, this powder-metallurgical plant looks very unlike the traditional factory, the lofty premises and the light colours used for coating interior surfaces and mechanical equipment producing an almost laboratory-like atmosphere. The plant is also an outstanding example of highly rationalised production planning. Manual work has been reduced to a minimum—one-third of the staff are engineers and office clerks—and most of the complex manufacturing processes are handled by ingenious machines, practically all of them being made to the company's own designs. The factory is largely a self-contained unit, including a complete electrolysis plant for producing the hydrogen required at the various production stages. The large-scale utilisation of hydrogen has necessitated the installation of several miles of tubing and special safety devices, including over 1,000 fire-alarm contacts and carbon-dioxide flushing nozzles.

The factory receives the raw material in the form of a high-grade Swedish tungsten ore known as Scheelite, which is subjected to a series of processes—filtration, drying, crushing, heating, reduction, and mixing with soot (for carburisation) and cobalt—until it is turned out as a blackish powder ready for pressing. Subsequently heated at a temperature of about 1,000° C. (1,850° F.) it becomes pre-cemented, acquiring a consistency similar to that of chalk. In this state the product can be worked into any desired shape before final cementation, which takes place at a temperature of about 1,500° C. (2,750° F.). The utmost precision is required at this stage of the process, as the cementation causes a 20% shrinkage of the product. In the course of the entire manufacturing procedure samples of every lot are continuously subjected to control, while final inspection includes microscopical analysis and X-ray examination.

Most of the output of Coromant, which comprises bits for rock-drill steels, milling cutters, reamers, stamping tools, wear resistant parts, etc., and also for dental burrs, is earmarked for export as semi-manufactures or finished products. Major customers in Europe are Britain, France and Italy, the U.S.A. also purchasing sizeable quantities. In addition to four manufacturing plants in Sweden, the Sandvik Works run factories for making rock drills in Canada and South Africa.

Together with Atlas Diesel, the Swedish pneumatic-tool specialists, Sandvik has developed the famous "Swedish Tunnelling Method" now used in large-scale rock-blasting operations all over the world. A striking example of the wide application of Coromant for rock drilling is offered by the fact that no less than 180,000 kilometres (112,000 miles) of bore holes were driven with Coromant drills in 1953, equivalent to 14 holes from North to South Pole.

New Aluminium Furnace in Hungary

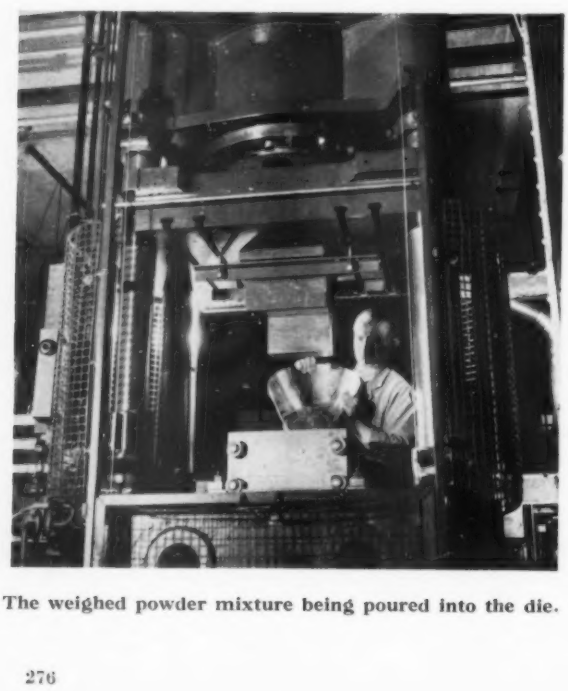
THE second furnace of the Maszobal Aluminium works in Tatabánya, Hungary, was put into production in May. It is claimed to produce metal of 99·99% aluminium content.

Heavy Alloy Production

New Plant in Operation at G.E.C.

Fighter aircraft showing positions of aileron and elevator balances.

PRIOR to World War II, there was developed in the Research Laboratories of the General Electric Co., Ltd., at Wembley, a material which is now known as G.E.C. Heavy Alloy. It was originally intended for a purely medical use, as a protective material for absorbing the potentially dangerous gamma radiation emitted by radium sources. Lead was formerly used, and still is for many applications, but occasions arose when it was impossible to get sufficient lead in the available space to provide complete protection. This difficulty could only be overcome by the use of a material of higher specific gravity, since, for any desired degree of absorption of gamma radiation, the thicknesses of various alternative metals that would be required are inversely proportional to their respective densities. Precious metals such as gold and platinum have much higher densities than lead, but they are very expensive to use in comparatively large masses. Tungsten has a density of the same order as that of gold, but the straightforward application of this material was not feasible owing to the difficulties of melting and casting the masses involved, and to the impossibility of machining tungsten. The G.E.C. Laboratories had, of course, considerable experience in the production of tungsten lamp filaments, using powder metallurgy methods of producing massive tungsten, and it was decided to attempt to turn tungsten into an engineering material by adding powdered nickel or nickel and copper to the powdered tungsten before sintering.



The weighed powder mixture being poured into the die.

With 90% tungsten, the specific gravity of the sintered product is 16·5–17g./cc. (compared with 11·4 for lead), and the outcome of this experimental work has been the development of a material of this density, with a tensile strength of 42 tons/sq. in., a yield point of 38 tons/sq. in., and a coefficient of expansion (20–420° C.) of $5 \cdot 6 \times 10^{-6}$. Moreover, the product can be machined, preferably with carbide-tipped tools, like any normal engineering material. Although G.E.C. heavy alloy is resistant to atmospheric corrosion, it can be given any of the usual finishes, such as nickel, chromium or cadmium plating, should such a procedure be considered necessary for the sake of appearance.

Manufacture

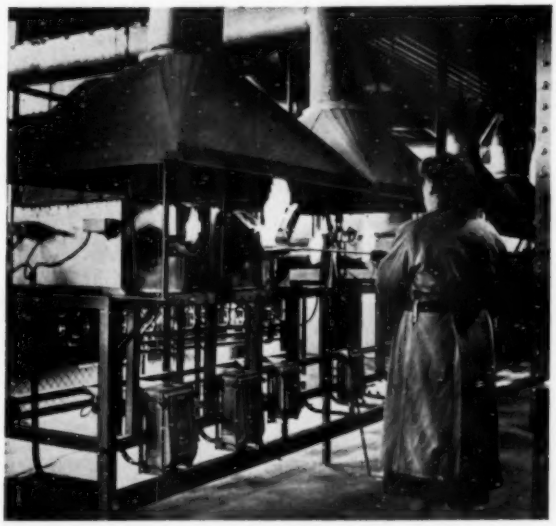
A considerable amount of this material was made during the war, for applications which will be referred to later, in a pilot plant housed in the Research Laboratories. It was foreseen, however, that demand was likely to increase, and, in spite of the fact that tungsten was in short supply, it was decided to transfer the manufacture of heavy alloy to the Osram-G.E.C. Metals Factory at Wembley, where, now that tungsten is more plentiful, the new plant is in full-scale production.

Heavy alloy is made by pressing a powder mixture containing 90% tungsten to the required shape, followed by sintering, and in order to ensure reproducible results, the constituent powders must satisfy rigid specifications, and must then be mixed and prepared carefully. If these conditions are not closely observed, the final product will be of variable density, and may also be blistered. Effective control, however, results in a material with a density which is constant to within $\pm 1\%$.

After sieving, the powders are thoroughly mixed in a Beken mixer, which is heated and thermostatically

controlled. Paraffin wax is then added to assist in the pressing operation, and the mixing continued. The waxed powder is then transferred to a food-type mixer where any agglomerates of wax are broken up. Each batch of powder is identified so that, should any difficulties arise at a later stage, they can be related to the material used.

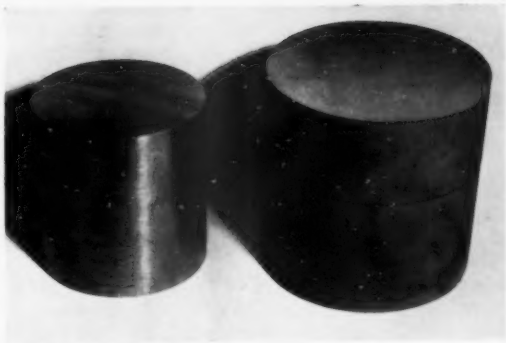
The compacts are pressed to shape on hydraulic presses, at a pressure of 5 tons/sq. in. This calls for somewhat massive dies, and solid die steel is preferred to case-hardened mild steel for their construction. The packing ratio is $2\frac{1}{2}$: 1, i.e., in the making of a 1 in. high block, the die must be filled to a depth of $2\frac{1}{2}$ in. Auto-ejection presses are used, the range comprising 350 and 250-ton four-column Bradley & Turton presses, a 125-ton four-column Daniels press, and a 60-ton Mills Oilaulic press. In addition to pressing compacts, the Oilaulic press is used for hot-straightening, and for this purpose an electric furnace is mounted alongside it. The care exercised at the mixing stage is also called for in pressing, and the charges for each mould are accurately weighed. In certain instances, effective control is achieved by overfilling the mould and sweeping off the powder level with the top.



View of the sintering furnaces.

After pressing, the products are capable of being handled, but are not difficult to damage. The next operation in the manufacturing sequence is termed pre-sintering, and consists of heating the compact, in an atmosphere of hydrogen, to a temperature in the region of 900° C., in the course of which the wax is burnt out. The 11 furnaces are of the resistance type, wound with nickel-chromium alloy, and the temperature is controlled by the operative by means of Brentford variable auto-transformers. After the pre-sintering operation, the material is much stronger, and cutting operations using flexible disc abrasive wheels are advantageously carried out at this stage, where it is necessary to cut large blocks into smaller ones, or to split two components pressed as one compact.

The final stage in the manufacture of heavy alloy is a high-temperature sintering operation carried out at



Heavy alloy compact before (right) and after sintering : note the extent of the shrinkage

1,450° C. This again is carried out in a hydrogen atmosphere, the gas being drawn from the works hydrogen plant, as is that used to protect the molybdenum windings of the sintering furnaces. There are 10 batch type furnaces—two with tubular chambers and the rest wound on D-shaped muffles—and 6 tube furnaces for continuous operation. The latter have a water-cooled chamber at the end into which the shapes are passed when sintering is complete. The furnaces are again controlled by manually-operated Brentford auto-transformers. From the pressed compact to the sintered product there is a 20% linear reduction in size, but the shape is retained. Allowance must, of course, be made for this shrinkage in designing the original die.

Any turning, shaping, milling, drilling or tapping is carried out after sintering, and the product is then ready for inspection and despatch.

Applications and Future Trends

Heavy alloy, as has been stated, was developed for use in radio-therapy, and this is still an important application, along with its use in the gamma radiology of castings, welds, etc., which has been given an impetus in recent years by the availability of radioactive isotopes such as Cobalt 60. In this field, heavy alloy is used in the construction of the "bombs" which house the radioactive source when not in use.

A large percentage of the output is now used in mass balancing work in aeronautical engineering, in both airframes and engines, whether of the piston or turbine variety. The new material made possible the design of

The rotor of the Sperry electric gyro horizon consists of the squirrel cage of a 3-phase induction motor housed in a cup of heavy alloy.

mass balances which could be contained within the wing, fin or tailplane, thus eliminating drag. Other aeronautical applications include a device for preventing the pilot from imposing a vertical acceleration on the aircraft greater than a critical value; the Maxaret automatic brake control unit; and, perhaps the most remarkable of all, the Sperry electric gyro horizons, where the rotor is tested at 30,000 r.p.m. for an operational speed of 22,000 r.p.m.

This material also has applications in other fields. It is, for instance, an ideal material for the arcing contacts of oil-immersed heavy-current circuit breakers, where it has proved very resistant to the destructive action of the arc. The moving parts of all kinds of machine, from the crankshafts of racing cars to variable pitch propellers are balanced with its help, and it has been similarly used in centrifugal clutches and vibration dampers.

For a long time heavy alloy remained unmodified, whilst it fulfilled the requirements of radiation and mass balance applications, but with extension of its use there came a demand for properties not available in the original alloy. For many aeronautical applications the highest possible density and improved mechanical properties were required, and the latest modification, which contains more tungsten and different alloying constituents, has a higher density and improved mechanical properties when compared with the figures quoted above for the "standard" material. One disadvantage of the method of manufacture outlined above is the limitation on the shape and form of pressed compacts, and it is interesting to learn that the modified alloy is capable of being swaged into rod and rolled into sheets of limited size, in which form it may have increasing radiological applications.

Correspondence

Hydrogen in Weld Metal

The Editor, METALLURGIA,
Sir,

I have read with great interest the article "Evolution of Hydrogen from Weld Metal," by K. Winterton and C. L. M. Cottrell, in your January, 1954 edition and feel that it will prove most useful to electrode designers, manufacturers and users alike. There are still certain points, however, which might repay further investigation. Although not familiar with the iron-oxygen-hydrogen thermal equilibrium diagram, I doubt whether the hydrogen present, in the presence also of oxygen, will reduce scale—and, if it does, it will yield additional water vapour subject to dissociation: this would involve no reduction in the amount of free hydrogen present. The presence of hydrocarbons would even be expected to increase the amount of free hydrogen (by dissociation of the water vapour formed as a combustion product of the oil); if it reduces the quantity of hydrogen in the weld metal, there must be another unknown, but rather efficacious factor concerned, and enlightenment on this matter might lead to still better electrode coatings. Perhaps some coating on the plate, containing no hydrogen, could lead to improved hydrogen control, more so than an improvement in electrode coating. (An introductory experiment would be the repetition of tests M 2 and B 13, with the oil on the electrode instead of on the plate).

Finally, I am not sure whether there is justification for taking Fig. 4 as a numerical basis for fixing the danger limit at 2·5–5 ml./100 g. and for declaring a further increment to be harmless. Fig. 4 is expressedly valid for one atmosphere, whereas it is most probable that the hydrogen in this case is evolved against considerable pressure, which increases the solubility in proportion to the square root of the pressure.

Yours faithfully,
G. Erber,
Beograd.

The Editor, METALLURGIA,
Sir,

Dr. Erber's comments were most interesting and very much to the point.

With respect to the effect of scale, our suggestion was that some of the scale becomes incorporated in the slag, and that a higher proportion of the available hydrogen finds its way into the slag. Something similar must happen in the case of an electrode with an oxidising coating, which usually gives a weld deposit with low hydrogen.

Hydrocarbons on the plate surface are not necessarily combusted with oxygen. Their effect may be to form molecular hydrogen (H_2) and some of the lower hydrocarbons with some suppression of water vapour (H_2O) in the arc atmosphere. The available evidence suggests that water vapour in the arc atmosphere is the most potent source of ionic hydrogen. This view is supported by the action of various chemicals used in mould dressings for the casting of bronzes and other alloys, where it has been shown that organic matter and tarry substances are not necessarily a source of hydrogen in the resultant casting, provided that oxygen and water vapour are missing.

Dr. Erber's suggestion for further tests, on the effect on weldability of materials used for coating the plate surfaces, seems to be one worth following up. Dr. Erber might be interested to refer to the limited amount of work reported in a recent article ("Effect of Plate Surface Condition on Weldability and Mechanical Properties": *Welding and Metal Fabrication*, March, 1953).

I would agree with much that Dr. Erber has to say about the critical value for hydrogen content. The value of 2·5 to 5 ml. of hydrogen per 100 grams. is an approximate figure, for which we have attempted to obtain some theoretical justification. It must be emphasised that this is intended to refer only to the case of hardened zone cracking. A good deal of work involving weldability testing, which we have undertaken at B.W.R.A., supports a critical value of about this amount.

Yours faithfully,
K. Winterton,
British Welding Research Association.
London, W.1.

THE SCOTTISH MACHINE TOOL CORPORATION, LTD., now have a Birmingham and District Office at 2 Sir Harry's Road, Edgbaston, Birmingham, 5. Telephone: Calthorpe 2541.

The Disposal of Toxic Industrial Waste

Some Methods for Cyanide used in the United States

By Francis J. Knight

RECENT prosecutions concerning the pollution of rivers by industrial waste have focussed attention on a problem which has arisen as a direct result of the increasing industrialisation of the country. Only fifty years ago, there were thriving salmon fisheries on the Humber and the Ouse, and time was when more than 8,000 salmon were taken from the Tees each year. The Mersey too was once fished for salmon, and in Scotland, the indentures for an apprentice to a Glasgow shipyard stipulated that " the employers shall not feed the said apprentice on fresh salmon and oysters more than thrice in any week." This is not a document from the Middle Ages—the indenture is dated 1901. Today, industrial pollution has resulted in the complete extinction of fish life in many of our rivers.

In far too many industrial plants, the only arrangement for disposing of highly toxic wastes is to channel them off, inadequately diluted, into the nearest public waterway. There is really very little excuse for this haphazard method of disposal, for, as a result of extensive research, modern industrial chemistry has provided adequate methods of neutralising the harmful effects of practically all industrial waste fluids. Even high concentrations of spent cyanide can now be readily reduced to a non-poisonous waste that can be channelled off into rivers or streams without causing any harm.

Handling of Cyanide Solutions

Cyanide waste resulting from electroplating operations, and from the heat treatment of steel involving immersion in a sodium cyanide bath, is the most deadly source of industrial poison. Chemical analysis of the contents of spent baths of concentrated plating solution has shown a cyanide content of more than 600 parts per million, and waste from the overflow of hot and cold rinse water tanks used in plating shops has been found to carry up to 500 parts per million. Rinsing waters from sodium cyanide baths used in the heat treatment process average 100 parts of cyanide per million.

The first requirement is, by proper plant design and layout, to prevent waste and spillage of toxic fluids, and to ensure that, when spillage does occur, the spilt fluid is never allowed to drain away into normal waste water outlets. Rinse waters need to be similarly controlled. Tanks containing cyanide or other poisons should be fitted with curbs or gutters to carry any spillage into the diluting tank, away from the normal outflow channels. Wherever possible, the flow of chemicals from the storage tanks to the plating and rinsing tanks should be gravitational as this arrangement avoids the need for pumps, with consequent risk of pollution by leakage and waste of expensive chemicals.

Once the toxic fluids are effectively isolated, there are various methods of neutralising them, suitability for use in any particular plant depending on such local circumstances as the quantity to be disposed of daily, the size and location of the plating rooms, available space for dilution tanks, justification of the capital expenditure on neutralisation, and such matters.

Conversion to Hydrocyanic Acid

One method of disposing of cyanide waste which is reasonably satisfactory where the factory is not in a built-up area, involves its conversion into volatile hydrocyanic acid by the addition of sulphuric acid to the water. In this process the cyanide waste stream is run into a large air-tight tank into which sulphuric acid drips through a perforated lead pipe. The tank is also provided with a wide diameter chimney pipe leading out into the open air. A blower is installed to give the necessary strong draught.

The action of the sulphuric acid solution liberates the volatile hydrogen cyanide, which is blown up through the chimney pipe into the atmosphere. The process can be accelerated by bubbling a stream of air through the solution while the reaction is taking place. The residual liquid is then drawn out into a diluting tank and agitated before being outpoured into the receiving river or sewer. To overcome any objection to the release of hydrogen cyanide into the atmosphere, the chimney stack is made as high as possible, and the outflow of the gas strictly regulated.

Oxidation to Cyanate

Another effective and economical method of disposal is the oxidation of cyanide to cyanate. This method, which has very wide industrial application, can readily be applied to the heavily cyanided residue from plating baths, as well as to the contaminated rinse waters.

Sodium chloride or chlorine is the chemical reagent used, and the oxidation process is practically instantaneous. The cyanates are then converted to carbon dioxide and nitrogen. Although chlorine is the more commonly used reagent, it has the slight disadvantage that the cyanide needs to stand for one or two hours, whereas the use of sodium chloride allows the second process to follow immediately after the first. It should be made clear that the use of chlorine as a reagent is not desirable at plants where the effluents vary in volume and in cyanide ion concentration, since the presence of substantial quantities of surplus chlorine in the outfall would result.

A variation of this method is in use at one of the largest United States motor manufacturing plants, where it is necessary only to reduce the cyanide content of rinse water to a stipulated or reasonable degree of tolerance, and where lack of floor space is a problem. Here, the cyanide is chlorinated to neutrality in holding tanks, under controlled conditions, before being released to sewage.

A chlorinator is installed on the workshop floor a few yards from the rinse tanks. A re-circulating pump to operate the chlorinator takes its suction from the bottom of the first of a series of rinse tanks, and pumps about

10 gallons a minute through the chlorinator injector and back into the top of the rinse tank. Additionally, clean water is added to the rinse tank at the rate of a gallon a minute, and a similar amount of chlorinated rinse water is drained away to sewage. Thus, the level of water in the tank is kept constant.

The rate of chlorination is adjusted by hand on the chlorinator to produce and maintain the desired chlorine residual in the rinse water. Caustic is applied as necessary to the re-circulating pump, to control the *p*H of the rinse tank water at 8·5–10. A *p*H measuring electrode shows a continuous indication and automatically sets off a bell alarm if the *p*H drops below 8·5. More caustic is then added until the position is restored.

Guard rails are installed round the apparatus and a ventilating hood is fitted above it.

So satisfactorily has this system operated that the second and subsequent rinse tanks contain practically no cyanide at all; indeed, tests, often show a slight chlorine residual. There is, also, the considerable advantage to the product that no cyanide contaminated water can cling to it through faulty rinsing and, in consequence, there is no danger of "spotting" or discolouration.

Oxidation by Calcium Hypochlorite

Yet another means of disposal is to turn the cyanide waste into cyanate by the use of calcium hypochlorite, diluting the mixture heavily before discharge into sewage. This is a reasonably satisfactory method for all but the most concentrated cyanide mixtures, and is particularly suitable for dealing with large quantities of cyanide waste.

This procedure is in use at a large United States factory which is situated some miles upstream from an important salmon fishing zone. The waste cyanide is first allowed to flow by gravity into two large wooden tanks, each of 3,000 gallons capacity. The calcium hypochlorite is added, the quantity being determined by the volume of solution to be treated and its *p*H value. A stainless steel pump with a capacity of 220 gallons per minute keeps the mixture agitated for half an hour.

Because of the vital need for conforming to laid down standards in order to avoid polluting the salmon fishing grounds, the mixture is next drained off into a second tank and tested for cyanide content with a quartz spectrophotometer.

For this ingenious test, chemical reagents that develop a red colour in the presence of cyanide are added to the treated mixture, through which monochromatic light is passed. If the solution is impure, the fact is indicated on an absorption meter. Thus, the treatment engineer is absolutely certain that the solution has been made harmless before it is poured into the dilution basin. River water is continuously pumped into this basin at the rate of 1,400 gallons per minute, and the cyanate is dispersed to the agreed tolerance of less than one part per million.

Besides cyanide waste, this particular factory has the problem of disposing of quantities of other toxic chemicals. This has been solved by the use of brick-lined sumps constructed in waste ground far away from the river, and in an area where there are no underground streams that could be polluted. Separate sumps are provided for acids, alkalis and dyes all of which are heavily diluted before being dumped.

Waste having too great a toxic content to be disposed of in the sumps is poured into strong leak-proof containers, sealed and dumped in the sea more than 100 miles from the shore in an area approved by the Federal Authorities.

Due to the importance of the salmon fisheries, the State regulations are stringent, and the Company have adopted a code of instructions which provide an ideal model. Below are set out some of the more important of the regulations governing the disposal of toxic waste:

(1) All effluents shall be diluted in a suitable basin; water from the waterway may be used as a diluting medium.

(2) Concentration of the basin discharge must be kept within the following limits:—

*p*H	6·5–8·5
Chromium (as chromate)	10 p.p.m. max.
Nickel (as chloride)	5 p.p.m. max.
Fluoride	100 p.p.m. max.
Cyanide (Na CN)	0·375 p.p.m. max.

(3) All effluents containing cyanide shall have the cyanide oxidised to a cyanate prior to dumping into the dilution basin.

(4) The ion concentration of the basin discharge must be checked by the Chemical Laboratory, who will operate the cyanide hypochlorite facilities as required.

(5) The laboratory shall notify the department concerned when a solution must be replaced, and shall order the method of disposal.

Whilst the particular method of neutralisation suitable for any individual plant must necessarily depend upon many local considerations, the various processes described make it clear that modern industrial chemistry can handle the problem of toxic waste disposal in almost any circumstances. The industrial chemist can help too, in approaching the problem from another angle—that of reducing to a minimum the processes involving the use of cyanide and similar toxic chemicals.

With public attention focussed as it is on this matter of river pollution, it is only prudent for factory managements voluntarily to take all practical measures to neutralise the toxic qualities of the waste for whose discharge into public water they are responsible. Time, trouble and capital outlay are involved, but the likely alternative is a rigid enforcement policy by Local Authorities that will compel the expenditure of a great deal more time and money.

British Firm Exhibits at U.S. Foundry Show

As a direct result of a recent visit to the U.S.A., Mr. Clifford Shaw, a Director of Shaw Processes, Ltd., was able to open negotiations for 15 firms to take out Shaw Process Licences, as well as to arouse considerable interest in the products of Clino Foundry Supplies, Ltd., one of the associated companies. It appears that it is possible to sell foundry equipment at a competitive price in North America, and Mr. Shaw believes there are prospects of opening up a good market for such equipment, and particularly for the Autoclino automatic shell moulding machine. To this end, he was fortunate in obtaining space in the Cleveland Foundry Show, and in getting Mr. Adam Dunlop, also a Director, to be in attendance on behalf of both firms. Equally gratifying interest was shown in Canada, where Mr. Winnet Boyd, the former chief designer of A. V. Roe (Canada), Ltd., was formally appointed to represent Shaw Processes, Ltd. in Canada. It will be interesting to see the relative value of direct representation in dollar earning countries as against exhibiting in available exhibitions here.

Diamond Die Profiloscope

New B.I.S.R.A. Development

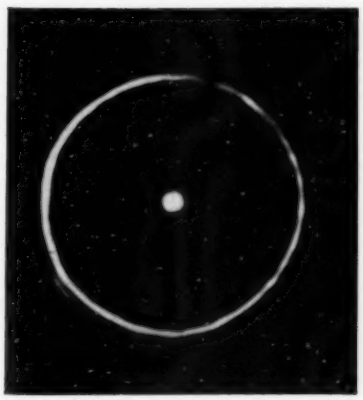
JUST over twelve months ago, there appeared on the market the B.I.S.R.A. Profiloscope, which had been developed for the examination of wire drawing die bores in order to ascertain the condition of the die and to check the angle of taper. This instrument has proved a useful item of equipment in the die shop, and is in use in Belgium, France, Germany, South Africa, Spain and Sweden, as well as extensively in the United Kingdom.

The Profiloscope is suitable for the examination of dies for the drawing of wire of 19 s.w.g. and upwards. There are, however, many dies in operation, some of them of the diamond type, for drawing finer wires, and to meet the need for an instrument which would provide the same information on these small dies that the Profiloscope does on the larger ones, the British Iron and Steel Research Association has developed the Diamond Die Profiloscope, which is capable of dealing with bores as small as 0·002 in. diameter. Like the earlier instrument it is being made by the Longworth Scientific Instrument Co., Ltd., of Abingdon, Berks.

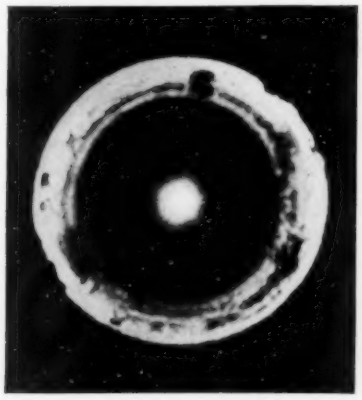
The principle on which both instruments operate is the simple one whereby a narrowly divergent light beam is passed through the die to be examined, on to a screen below. When the light passes vertically through the die, a small bright spot of light is seen, outside which is a dark band, outside which again is a narrow band of light, all these being concentric one with another. The innermost spot is due to direct illumination through the die hole and the outer band to internal reflection from the tapered region of the die. Changes in taper show as more concentric light circles, one for each taper, while a gradual change in taper causes a wider band of light. Scoring shows as lines radiating from the centre spot, while cracks and ringing also have distinctive and easily recognisable effects on the pattern.

In order to achieve satisfactory illumination of these small bores, it has been necessary to use a more intense source—a mercury vapour lamp—and to reduce the source/die and die/screen distances. Furthermore, because the mercury vapour lamp must be vertical, a mirror is used to deflect the light beam through the die. In the earlier instrument, the die angle is measured with the aid of a tilting die table, but in the Diamond Die Profiloscope the distance between the die and the screen is so small that the die tilting mechanism would cut off part of the image : oblique illumination in this case is obtained by tilting the mirror.

When the front-silvered mirror is rotated by means of the control knob on the front of the instrument, the light beam strikes the die obliquely. This has three effects. It intensifies the pattern of the image; it



Nearly perfect straight taper pattern ; no defects visible, but halo shows cross section of reduction zone not quite circular. Die angle is easily measured. Die diameter 0·0015 in.



Slightly thicker ring shows more curved profile. Surface defects at 1 and 4 o'clock. Faint light in the dark region at 8 o'clock probably indicates beginning of ring. Range of angles easily measured. Die diameter 0·0083 in.

Curved profile. Mottled effect shows poor surface finish or dirt. Confusion of lines in centre ring system shows irregular profile in throat or "parallel"; crack shows in relief section of die at 11 o'clock. Die diameter 0·016 in.

extends it to cover the sizing portion and the back relief; and it distorts the annulus and makes possible the determination of the die angle by a very simple measurement. The scale on the control knob is calibrated in 30 minute intervals and is easily read to 15 seconds or less by an unskilled operator.

The mirror on its holder and the control knob are the only moving parts in the new instrument, the die itself being held in a clip on which it can quickly be centred. Although the mercury vapour lamp is essential for the smallest bores, those down to 0·010 in. diameter can be satisfactorily examined with a tungsten filament lamp. The instrument is available with either or both light sources, the mercury vapour lamp, on the grounds of cost, being reserved for those cases where its use is essential to the attainment of satisfactory results.

The Diamond Die Profiloscope, like the B.I.S.R.A. Profiloscope, has the great advantage that it sets up quickly learned and easily recognised visual standards. After only a few minutes training an unskilled worker can use it, taking less than half a minute over a thorough inspection and measurement of each die. It extends almost to the bottom of the working range of wire drawing dies the advantages of a cheap, robust and simple instrument, essentially designed for use in the die shop of a normal wire drawing works.

Aluminium Alloys in Royal Yacht

ALUMINIUM alloys have been used structurally in H.M. Yacht *Britannia* for the bridge structure and for the funnel. The bridge structure is two tiers high, the lower tier being some 50 ft. in length, whilst the upper tier, containing the wheelhouse and navigating bridge, is approximately half this length. The bridge wings are continued outboard to the ship's side. Although the ship was designed at the Admiralty, the scantlings in general are based on merchant ship practice, and conform to the Rules of Lloyd's Register of Shipping. The scantlings of the aluminium alloy deckhouses have been derived from equivalent steel deckhouses of this size which would conform to good modern practice. Thus, there is the same factor of safety in the aluminium structure as there would be in the corresponding steel structure.

The required section modulus may, of course, be achieved in a variety of ways. Thus, the thickness of the plating may be varied when used in conjunction with a particular stiffening member, or the thickness of the plate may be kept constant whilst the geometrical properties of the stiffener are altered. Alternatively, both the plate thickness and stiffener properties may be varied simultaneously. It is worthwhile, however, when designing aluminium alloy structures, to ensure that material is used economically, and that a good strength/weight ratio is achieved. When such axioms are followed, the aluminium-alloy/steel weight ratio may well be between 0·36 and 0·42.

In the case of the ship now under review, the weight of aluminium alloy used for the bridge structure is about 15 tons, and the amount of steel which it replaces is estimated at 40 tons. The weight ratio is therefore 0·375. This ratio has largely been achieved by the use for deck beams and deckhouse stiffeners of bulb angles, which, compared with ordinary angles, possess higher section-modulus/weight ratios.

Thickness of the plating in the bridge structure is, in general, $\frac{1}{4}$ in. Thus, in changing from steel to aluminium alloy, the thickness of the plating is not appreciably increased. In designing small deckhouses in aluminium alloys which are unstressed except by way of locally applied loads, there need be no significant change in the scantlings from those used in steel construction, and the thickness of the plating may be that of a corresponding steel structure. This is especially true of an aluminium alloy deck which is sheathed with timber, since tests have shown that the resistance to compression instability of a sheathed deck depends to a considerable extent on the timber bolted to the plating*. A further attractive factor in the choice of suitable scantlings when designing in aluminium alloys is that no corrosion allowance need be added.

It is not possible to describe in full all the constructional details of the deckhouses, but it is interesting to mention that the dimensions of the plates used vary from 8 ft. 5 in. × 75 in. to 29 ft. 3 in. × 60 in., and thicknesses vary from 0·25 in. to 0·45 in. The alloy conforms to the BS : GE Specification NP5/6, which is rolled to the tentative requirements of Lloyd's Register of Shipping. The sections used for beams and stiffeners were all extruded in alloys conforming to BS : GE Specifications HE10–WP and NE6. The scantlings included 2 × 2 × $\frac{1}{4}$ in. ordinary angles and 4 × 2$\frac{1}{2}$ × $\frac{1}{4}$ in. bulb angles.

The deckhouses were erected at the ship plate by plate, and are all of riveted construction. In the house sides, butt straps are employed to give a flush outer surface, these being single riveted and the plate edges caulked. The deck plating was joggled down at the laps, the beams remaining fair, but slotted in way of the plating overlaps. This method of construction presents a flush surface on which the wooden deck sheathing may easily be laid. Rivets are $\frac{1}{2}$ in. and $\frac{5}{8}$ in. in diameter, the alloy conforming to NR6 specification: they were all driven cold pneumatically. Aluminium alloy sidelights have been fitted, the hinge pins and swing bolts of which are of stainless steel.

The funnel, in which 7 tons of aluminium alloy have been used, is 26 ft. 3 in. long and 32 ft. 6 in. high. It is again of flush riveted construction, the bottom strakes being $\frac{5}{16}$ in. thick, whilst the upper strakes are $\frac{1}{4}$ in. thick. The funnel framing and seats for the equipment housed within the funnel called for some heavy extruded sections, ranging up to 11 × 3 in. channel. All the extruded sections conformed to NE6.

In addition to the structural use described above, aluminium alloys were widely used for internal fittings. The cold rooms have been lined with aluminium alloy sheet, and this material has also been used throughout the vessel for kit lockers, bins and tables and other furniture, and store rooms, including shelving. Furniture for the officers' and staff cabins will also be of aluminium alloy. For this interior work, a total of some 8$\frac{1}{2}$ tons of sheet has been used.

The greater portion of the plate, sheet and sections has been supplied by The British Aluminium Co. Ltd.

* "Aluminium as a Shipbuilding Material" by E. C. B. Corlett, M.A., Ph.D., *Transactions of the N.E. Cost. Inst. Engineers and Shipbuilders.* **68.**

Heat Treatment Furnace Developments

Recent Installations for Ferrous and Non-Ferrous Metals

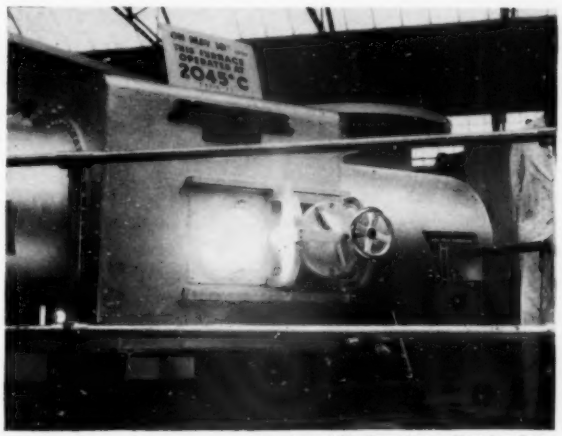
Although furnace builders have been busy with production work during the past twelve months, they have not neglected the experimental side, and a number of interesting developments have resulted, notable among them being a high temperature furnace fired by town's gas. Considerable progress has been made in all sections of the industry, and the present review, whilst not complete, indicates the general trend in this field.

SO many factors are involved in the heat treatment of ferrous and non-ferrous components that the design of suitable furnaces is very complex. Whatever form of heat is applied, the manner in which it reaches the surface of the component undergoing treatment is of great importance. Closely associated are those factors which concern time and rate of heating and cooling. Ideal conditions can more nearly be approached when a furnace is to be designed for the heat treatment of mass-produced components exactly similar in size and design and of uniform section. Even so, the heating or cooling medium must be applied uniformly to the whole surface of each individual component, at the same temperature, at the same time, and in the same atmosphere, to produce uniformly heat treated products. Almost invariably a compromise has to be made to obtain the best results that variable conditions will permit.

It must be remembered that heat treatment is not solely concerned with the final heating and cooling operations to produce the properties desired in the finished product, but that the process begins with the initial operation preparatory to fabricating. This initial heating may have a marked influence on subsequent heat treatment and machining operations and on the results obtained in service from the finished product.

Heat treatment furnace builders have been required to keep in line with improved techniques in many metallurgical operations following improvement in the quality of steel and the development of new heat-treatable non-ferrous alloys in recent years. The necessity of controlling grain-size, and the surface conditions of materials which have been heat treated, have also given rise to many new and interesting problems. And to bring about improved heat treating methods and techniques to meet such conditions, variables such as furnace temperature, furnace atmosphere, heating time, cooling rate, and quenching method, must be closely controlled. The changes that have been made to meet these conditions have not only been carried out by improvements in the design of heat treatment furnaces; by the use of better and more rigidly controlled pyrometers of all types; by the development and applications of controlled atmospheres; and by the use of proper quenching media and equipment; but also by a better understanding of the principles of heat treatment as applied to various metals and alloys. Although the following review of heat treatment furnace developments and installations during the past year is somewhat limited, as it must be, it indicates that in design and construction, furnace builders in this country are in the forefront of progress.

One result of investigations that have been in hand for some time is the recent development, by the Incandescent



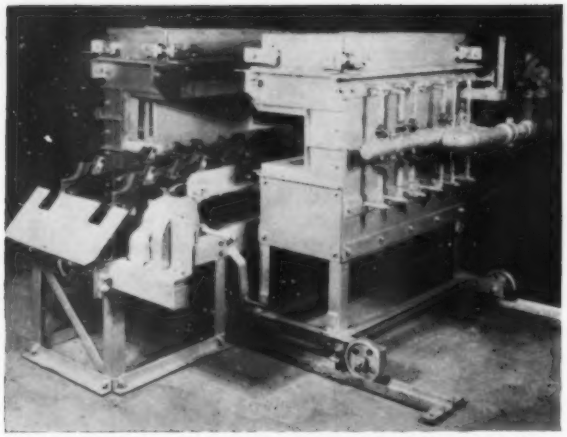
Courtesy of The Incandescent Heat Co., Ltd.

Fig. 1.—A new high temperature furnace fired by town's gas.

Heat, Co., Ltd., of a high temperature furnace, which has broken all temperature records for gas-fired furnaces. It operates on ordinary town's gas and has reached a temperature of 2,100° C. without oxygen enrichment; intense heat recovery is involved, the air being preheated to a temperature about the melting point of steel before gas is injected and mixed with it. One difficulty in designing this furnace was that ordinary high temperature firebricks melt well below the contemplated temperature, but this has been overcome and, as will be noted in Fig. 1, successfully. This new super-hot furnace opens up possibilities in the field of high temperature research. It can be used to manufacture firebricks to withstand ultra-high temperatures, special materials for gas turbine blades, gas synthesis, etc. It has a working chamber $14\frac{1}{2} \times 14\frac{1}{2} \times 14\frac{1}{2}$ in. and its efficiency is such that, despite the high working temperature, the waste gas temperature is only 250° C.

Reheating Furnaces

Mention has already been made of the importance of preliminary heating of the cold stock prior to rolling, extruding, stamping, forging and pressing operations. The working temperature employed is governed by the material to be heated and may be critical; hence, accurate heat distribution and temperature control of reheating furnaces is essential. In Fig. 2, for instance, is seen a plant used for heating the ends of tubes for shrinking onto bushes. It is designed to burn town's gas at a pressure of $\frac{2}{3}$ in. w.g., in conjunction with pressure air at 18 in. w.g. and operates at a temperature



Courtesy of Brayshaw Furnaces & Tools, Ltd.

Fig. 2.—A furnace designed for heating the ends of tubes for shrinking onto bushes.

of 650/700° C. The plant comprises two furnace units, each with a slot 36 in. long and capable of accommodating tubes up to 7½ in. diameter. As will be noted, each section is mounted on wheels to allow adjustments for the length of the tubes, the latter being accommodated on a simple conveyor gear between the separate units. Another interesting example is the slotted-opening bar heating furnace, shown in Fig. 3. This is a very compact portable and space-saving furnace giving a high weight of output per square foot of hearth area, with close degree of uniformity throughout the working zone. An insulated shield is provided at the front of the furnace lined with hot face insulating refractories, behind which the products exhausted through the slotted openings pass; an arrangement which provides favourable working conditions.

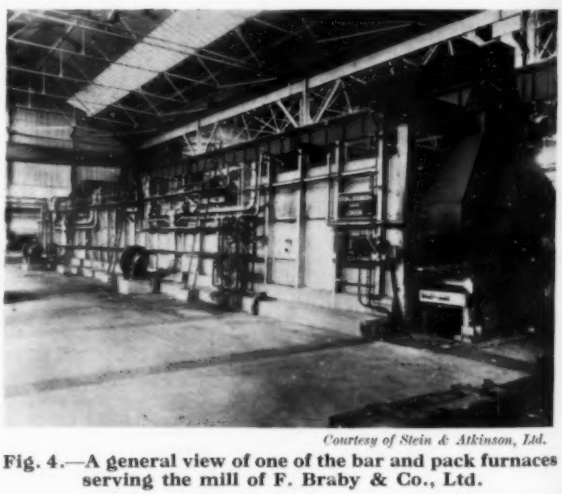
The bar and pack furnaces serving the rolling mill at Messrs. Fredk. Braby & Co., Ltd., Glasgow, are examples of the much larger types of reheating furnaces used in steelworks. These furnaces are of the walking beam type, the beams and their method of operation being covered by British patents. The beams are supported on quadrants carried off rocking saddles, the up and down movement of the beams being obtained by rocking the supporting saddles, and the travel of the beams, and hence the stock, by alternatively moving the beams backwards and forwards on their quadrants. Their movement forms a rectangle, and the stock is transferred from one group to the other in the mid-position of the lift and lower motions when all beams are moving truly vertically; thus there is no drag of the refractory on the stock, and there is no marking of the latter. Two groups of beams move simultaneously but out of phase with each other, the group which is raised advancing the stock, while the lower group returns out of contact with the stock. Should necessity arise, the drive to the beams can be reversed and the stock returned to the charging end of the furnace.

Courtesy of Thermic Equipment & Engineering Co., Ltd.

Fig. 3.—Slotted opening bar heating furnace.

The bar furnace shown in Fig. 4, which is typical of this installation, is designed for an output of 20 tons per hour and consists of five beams; the chambers have four firing zones to give maximum flexibility for varying outputs. The firing rate of the two chambers at the charging end is manually controlled, but the discharge end is automatic. The beams place a bar in a predetermined position, depending on its width, by means of a photo-electric cell, which stops the beam movement with all beams level, thus preventing the bars from bending while lying in the furnace awaiting the mill. All furnaces are oil-fired, using 200 secs. fuel oil. Furnaces employing this system of beam movement are in use at the Grimesthorpe works of the English Steel Corporation for spring hardening, and at Messrs. Braithwaite & Co. Ltd.'s works, Newport, for plate pressing.

In addition to the need for uniformity in reheating for working, special attention has been given to the mechanical handling of material with a view to high production with the minimum operating staff. As will be noted elsewhere in this review, facilities for dealing with the charging and discharging of heating furnaces are usually incorporated in the furnace plant, but owing to variations in size and shape of ingots or billets being reheated, entirely separate mechanism for this purpose may be more efficient. To meet this requirement the mobile forging manipulator has been developed. Designed and constructed by The Wellman Smith Owen Engineering Corporation, Ltd., for charging and discharging reheating furnaces and subsequently handling and manipulating the ingots and billets under the forging hammer or press, a new machine of this type incorporates many outstanding features.

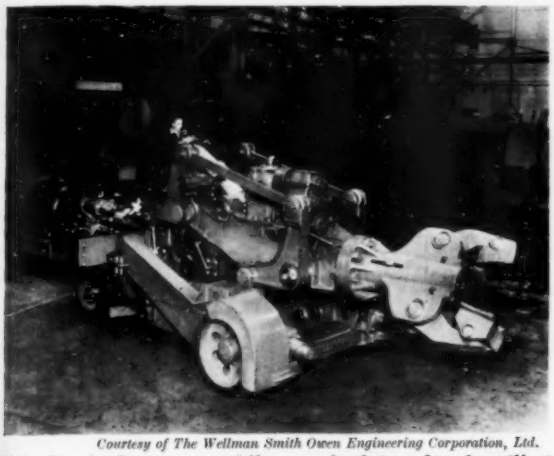


Courtesy of Stein & Atkinson, Ltd.

Fig. 4.—A general view of one of the bar and pack furnaces serving the mill of F. Braby & Co., Ltd.

The manipulator is substantially constructed to

withstand the arduous nature of its work, and is protected mechanically and hydraulically against overload or shock. Weighing approximately 24 tons (unladen) the machine is able to travel freely around its operating area and can be equipped with either electric motor or diesel engine prime mover. It has six separate motions, all of which are hydraulically powered. These are grip, parallel hoist, rocking hoist, bar turning, travelling and steering. The control unit is placed to one side of the machine affording good visibility for the operator when travelling around the operating area. The height of the control position is such that the operator not only has a good view of the gripped workpiece when forging, but is also able to see clearly the grips through the doorway when reaching into the furnace to take up



Courtesy of The Wellman Smith Owen Engineering Corporation, Ltd.

Fig. 5.—A five-ton mobile manipulator for handling stock for reheating and forging.

or put down the ingot or billet. The machine shown in Fig. 5 is the largest of this type to be supplied by a British company. In addition to forging manipulators, the Wellman Corporation design and build other mobile machines including plate, billet, ingot, slab and tyre cheese handlers.

Stress Relieving and Normalising

In many fabricating processes, where heat is applied locally, residual stresses are set up and heat treatment to relieve these stresses is usually necessary; this is particularly true of welded components used in chemical engineering, which are liable in service to stress corrosion cracking or embrittlement at the weld.

Fig 6 shows a furnace specially designed for stress relieving gas and water tubes up to 6 ft. diameter and 24 ft. long. As is well known, the thermal efficiency of any furnace is influenced by the heat losses through the structure and, therefore, it follows that the smallest area practicable, through which heat can escape, is very desirable. For this reason the furnace has been made circular (see Fig. 7) and it is tangentially fired with Min-O-Max automatic proportioning gas burners which, together with the extensive use of lightweight insulating refractories, has resulted in fast heating times and very economical fuel consumptions.

The design of this furnace lends itself admirably to dealing with tubes of varying length, as on short work only the burners in the first zone may be necessary. The method of charging and discharging over rollers outside

Courtesy of The Dowson & Mason Gas Plant Co., Ltd.

Fig. 6.—Gas-fired tube heating furnace for stress relieving or annealing large diameter tubes.

the furnace, with Carborundum skids on the hearth, will be of interest to those who require to stress relieve or heat treat cylindrical structures, like tanks, as the expense of a bogie is saved.

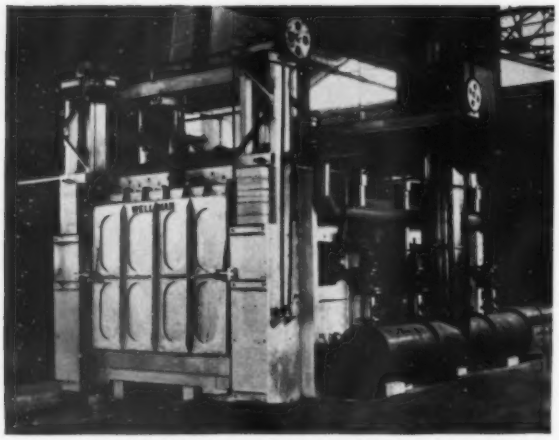
The bulk of the work heated by this furnace comprises mild steel tubes 62 in. diameter × $\frac{3}{8}$ in. wall thickness × 15 ft. long. For stress relieving it is operated at 650° C., and it is noteworthy that this gas-fired furnace can heat a tube to temperature in two hours from starting up. It is occasionally used for normalising in the 950° C. range.

Annealing Furnaces

The double bogie annealing furnace illustrated in Fig. 8 is capable of heating a charge of 12 tons of assorted castings to 1,050° C., in six hours. The furnace chamber

Courtesy of The Dowson & Mason Gas Plant Co., Ltd.

Fig. 7.—Inside view of tube furnace.



Courtesy of The Wellman Smith Owen Engineering Corporation, Ltd.

Fig. 8.—Double bogie furnace for annealing castings.

is 15 ft. long × 8 ft. wide × 5 ft. 6 in. high, and the bogie hearth measures 15 ft. long × 7 ft. 6 in. wide. Before discharging, the castings are cooled to 700° C., and interruption of the furnace operation, with consequent heat losses, is reduced to a minimum by charging one bogie into the furnace at the same time as the other bogie is discharged. The furnace whose roof, doors and bogies are amply insulated, is fired with hot raw producer gas, and has a thermal efficiency of 25%. The furnace doors are equipped with dippers extending into the end sand seals of the bogie, and a further sand seal, forming an integral part of the door arch plate, is sealed by means of a cast iron dipper attached to the top of the furnace door. Hand-operated cam-shaped clamps ensure the furnace door fitting tightly on the frame.

Gas is conveyed to the furnace in an overhead refractory-lined mild steel main and a downtake on each side of the furnace connects the horizontal gas mains, thereby ensuring equal distribution of the gas to the furnace. Firing is by means of four Wellman Basequip K burners, mounted on each side of the furnace. These burners ensure a very high degree of combustion efficiency, due to the rapid mixing of the pressure air—

Courtesy of The General Electric Co., Ltd.

Fig. 9.—A general view of the wire annealing shop at Richard Johnson & Nephew, Ltd., with new plant on the right.

through tangentially arranged jets—into the central gas stream. Combustion products are taken from the furnace through eight exhaust ports at bogie level on each side of the furnace.

The annealing plant supplied last year to Richard Johnson & Nephew, Ltd., consists of two vertical cylindrical furnaces, each rated at 140 kW, and ten annealing containers, each more than 11 ft. long, nearly 3 ft. in diameter and capable of taking up to four tons of wire. These furnaces operate up to 850° C., and are equipped with automatic temperature recording and controlling gear. A feature of this plant is the use of fans to speed the scale-free annealing process. Preheating of the newly charged containers is carried out in a recuperator pit, where forced air circulation speeds the transfer of heat from hot containers removed from the

Courtesy of The General Electric Co., Ltd.

Fig. 10.—An annealing container charged with copper strip being lowered into a furnace at the Kynoch works of Imperial Chemical Industries, Ltd.

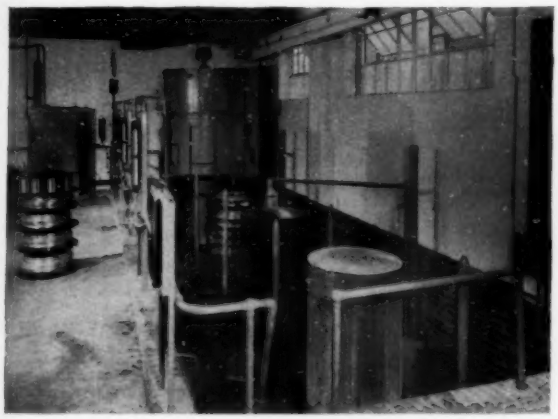
furnaces. Each container has a fan mounted in the lid to increase the circulation of the controlled atmosphere around the wire and reduce heating time in the furnaces. The final cooling of the wire prior to its removal from a container is assisted by forced air flow through the cooling pit. Fig. 9 shows a general view of the annealing shop, the new plant being on the right. On the left are G.E.C. vertical cylindrical furnaces which have been in operation for many years.

A similar plant for bright annealing copper strip is installed at the Kynoch works of the Metals Division of Imperial Chemical Industries, Ltd., and handles charges weighing up to 3 tons. It is rated 275 kW and takes annealing containers over 12 ft. long. Several containers are used to allow a continuous cycle of operation during which the coils of copper strip are maintained in an atmosphere of cracked and burnt ammonia. Special handling gear is used to up-end the coils on to carrier

plates to facilitate charging of the containers, one of which, ready for the furnace, is shown in Fig. 10.

A bell-type of annealing equipment by Electric Resistance Furnace Co., Ltd., for the bright annealing of wire in coils is shown in Fig. 11. It is a recent installation in the works of Johnson Matthey & Co., Ltd., and the materials handled with this equipment include silver and its alloys, low-temperature brazing alloys and electrical resistance materials. The main equipment comprises a bell furnace and four bases with gas-tight containers and circulating fans. The work dimensions of the bases are 28 in. diameter and 42 in. high, and the furnace is rated at 86 kW. As will be noted in the illustration, special charge carriers are used for supporting the coils of wire. The controlled atmosphere plant used in this case is an I.C.I. regenerative ammonia burner installation.

A quite different type of furnace for annealing brass strip is shown in Fig. 12. It is a twin track recuperative walking beam continuous furnace. The illustration shows the charge and discharge doors of the furnace, which are side by side since the charge travel is in the



Courtesy of Johnson, Matthey & Co., Ltd.

Fig. 11.—An Efco bell furnace installation for bright annealing coils of wire.

form of a "U." The ingoing walking beam conveys the charge in steps to the far end of the furnace where it is moved across on a hydraulically operated transfer car to the outgoing beam. At the discharge end, the coils pass through a water spray cooling vestibule. High working efficiences are obtained by recuperating heat from the outgoing coils on the last section of the chamber and imparting it to the coils which are passing through the first section of the furnace. Air circulating fans are fitted in the roof of the main heating portion of the furnace while fans are also used for effecting the heat transfer in the recuperation section.

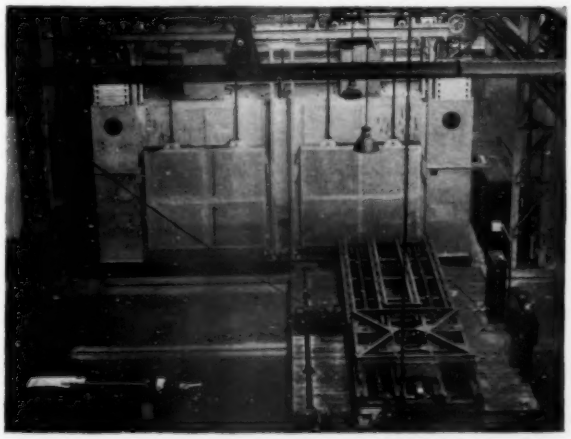
The large twin furnace shown in Fig. 13 has been installed in the Rogerstone works of the Northern Aluminium Co., Ltd., for annealing coiled aluminium strip. Each chamber is rated at 1,000 kW and is divided into six independent zones for temperature control purposes. Each chamber is 36 ft. long, 9 ft. wide and 7 ft. high and is designed to accommodate 20 coils 3 ft. 6 in. outside diameter and 10 in. wall thickness, each coil weighing 4,000 lb. To cut down wear and tear on the zone contactors, star delta switching is incorporated

Courtesy of G.W.B. Furnaces, Ltd.

Fig. 12.—A twin track recuperative walking beam unit for annealing coiled brass strip.

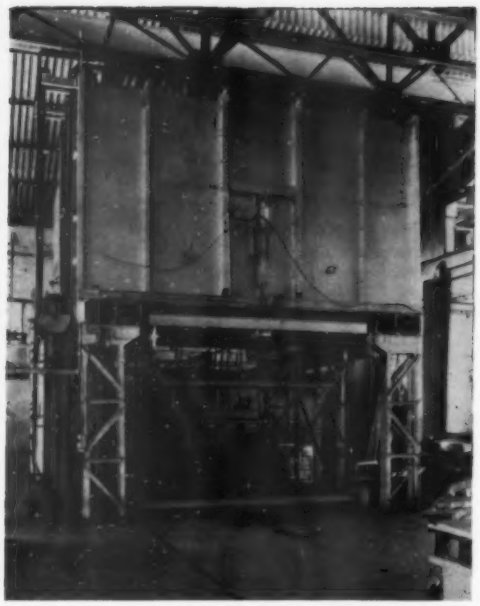
to change over the connections from delta to star when thermal uniformity at annealing temperature has been attained. This arrangement has the effect of reducing the electrical input to one-third of the maximum rating: thus, a considerable saving of electricity is effected. The heavy nickel-chromium strip heating elements are suspended from the arched roofs by means of hooks, and are arranged so that they are edgewise to the air flow. Forced air circulation is operated by means of fans in the roof which drive air over the heating elements, down the sidewall ducts, and up through the aluminium coils back into the fans for recirculation. The charge coils are carried on skips which roll into and out of the heating chambers on rollers fitted in the chamber hearths and on top of the charging machine. An electrically operated endless chain on the charger provides this motion by engaging on the charge skips.

For interstage and final annealing, the most usual conveyors are roller hearths and continuous mesh belts, and a Birlec roller-hearth furnace for the



Courtesy of G.W.B. Furnaces, Ltd.

Fig. 13.—A large twin-chambered furnace installed in the Northern Aluminium Co., Ltd.'s Rogerstone works for annealing coiled aluminium strip.



Courtesy of Brayshaw Furnaces & Tools, Ltd.

Fig. 14.—Electrically heated air recirculation type furnace for the precipitation treatment and annealing of aluminium alloy components.

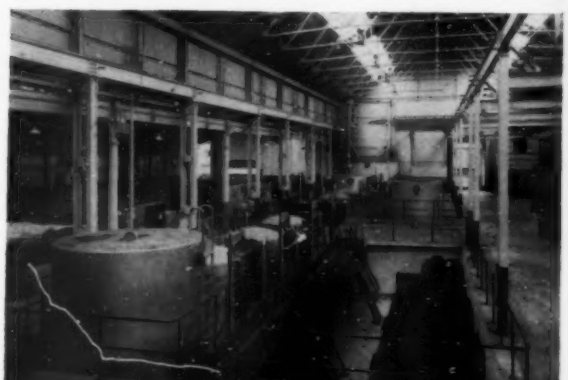
continuous annealing of brass tubes was recently installed in a works in Scotland. With a width of 42 in., this furnace is heated by gas-fired multi-jet tunnel burners, and is rated to anneal 3 tons per hour of brass tubes. It is noteworthy that a de-sulphurising unit, capable of treating 9,000 cu. ft./hr. of town's gas, has been supplied for this installation ; this unit, however, will be able to deal with the gas input of more than one furnace.

The furnace shown in Fig. 14 has been installed for the precipitation treatment and annealing of aluminium alloys. It is an electrically heated air recirculation furnace of the elevator type, in which the actual stock chamber is mounted on a superstructure approximately 9–10 ft. above ground level. Provision is made for rapid vertical quenching of the heat treated work in a pit-type quench tank below. The furnace has a working chamber 6 ft. wide × 11 ft. long × 9 ft. 6 in. high and is suitable for operating at temperatures from 200° C. to 650° C. The bottom of the furnace is designed in the form of a retractable carriage which can be raised, when in position, to form a seal to the furnace chamber. The work for treatment is loaded on a work trolley and pneumatically hoisted into the working chamber.

In an earlier review, reference was made to the development of flash-annealing furnaces for the treatment of aluminium and aluminium alloy sheets and circles instead of the familiar pack annealing method. Several problems are associated with pack annealing in batch-type furnaces and it was with a view to overcoming these problems that the continuous flash-annealing furnace was developed, its function being to heat the metal to its annealing temperature in 2–3 minutes, thus giving rapid, even and uniform recrystallisation of the structure of the material, and then immediately to cool it so that the whole annealing process is complete in such a short time that grain growth is reduced to a minimum. The result is a finished product which is clean, undistorted and claimed to be metallurgically superior, and

Courtesy of Stordy Engineering, Ltd.

Fig. 15.—A flash annealing furnace for aluminium sheets and circles.



Courtesy of Birlec, Ltd.

Fig. 16.—Bell furnaces installed at Rylands Bros., Ltd., for bright annealing all grades of ferrous wire.

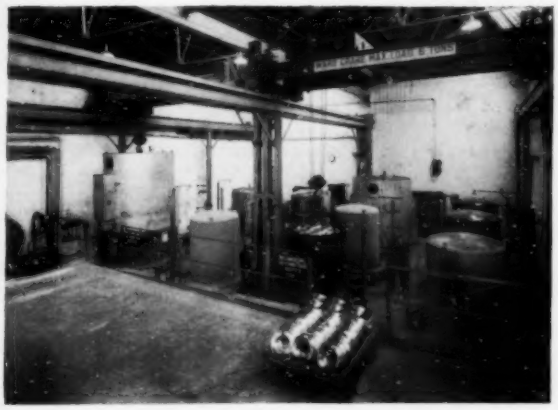
which, furthermore, is available for inspection and packing within a few minutes of the commencement of the heat treatment cycle. Fig. 15 illustrates a furnace of this type which is now in production, and is designed to handle sheets 2 m. (6 ft. 6 in.) wide and circles down to 125 mm. (5 in.) diameter at a rate of approximately 2 tons/hr. A smaller size, designed to handle sheets up to 1,220 mm. (4 ft.), is also in production.

The method of operation involves the feeding of single sheets continuously on to a loading conveyor which consists of a series of non-metallic ropes designed to receive the finished work without abrasion of the polished surface. The work is conveyed by means of the loading conveyor to a transfer point, where it is discharged on to the furnace conveyor ; these conveyors are interlaced and the transfer operation is accomplished smoothly and automatically. Considerable investigation has been devoted to the furnace conveyor, the object being to produce a conveyor which is capable of continuous operation at temperature with a minimum of

maintenance, and at the same time to provide a system which can handle highly polished work without abrasion.

The units so far in operation are all arranged for electric heating, and are provided with an intensive system of air circulation. The annealing procedure is laid down for each thickness of sheet and circle as a function of furnace temperature and time, and the conveyor drive is fitted with an infinitely variable speed control. The conveyor speed is shown on an indicator, suitably calibrated, so that adjustment for varying gauges of material is possible.

The bell furnaces for bright annealing ferrous wire, shown in Fig. 16, were installed at the Warrington works of Rylands Brothers, Ltd., and started up in 1953. The installation consists of three 300 kW. furnaces, each



Courtesy of Birlec, Ltd.

Fig. 17.—A bell furnace plant for bright annealing non-ferrous wire.

serving four hearths; the pit for an eventual fourth furnace will be noted. These furnaces are the largest cylindrical bell-type furnaces built by Birlec, Ltd., and have been incorporated in their standard range of sizes. This installation forms part of earlier installations of bell furnaces in these works, and is mainly concerned with the annealing of low carbon wire ranging from 20 s.w.g. to 3 s.w.g.; charge weights up to 6 tons can be accommodated on each furnace hearth.

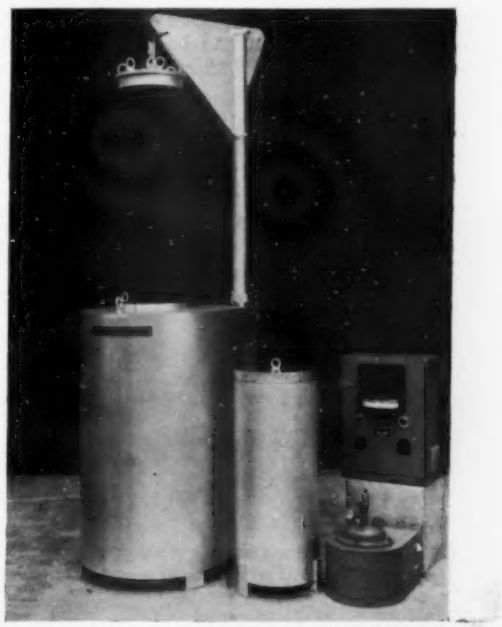
Another installation of similar bell-type furnaces is shown in Fig. 17. This comprises two 150 kW. furnaces, each operated with six hearths, used for bright annealing non-ferrous wire. The majority of its output is copper wire although some nickel silver wire is also treated. Each charge weighs about 35 cwt. and, working continuously, each furnace anneals about 1 ton per hour. The atmosphere for this plant is obtained from an I.C.I. ammonia plant, in which is incorporated a standard dual absorber Birlec Lectrodryer to maintain a sufficiently low dew point.

A smaller bell furnace installation is shown in Fig. 18; it is used for bright annealing steel rivets, small steel pressings and steel wire in coils. There are two charge bases with covers, the third base being a dummy for use during the heating up of the furnace. The bell furnace itself has a restricted vestibule to protect the heating elements and reduce heat losses. Gas entries and separate oil and sand seals are provided for the charge bases.

Courtesy of Wild-Barfield Electric Furnaces, Ltd.

Fig. 18.—A bell furnace installation used for bright annealing steel rivets.

For annealing comparatively small batches of non-ferrous components, ageing malleable castings, or other treatments within its capacity, the bright annealing furnace shown in Fig. 19 may be considered both economical and adaptable. It is a self-contained vertical loading furnace which is available in various sizes to operate at temperatures up to 1,000° C. A small electric steam generator is available to provide the necessary non-oxidising atmosphere, steam proving very satisfactory for this process, although hydrogen or other atmospheres may be employed. The furnace is complete with automatic control gear and a gantry for raising and lowering the work container, provision also being made for rapid quenching after removal.



Courtesy of Barlow-Whitney, Ltd.

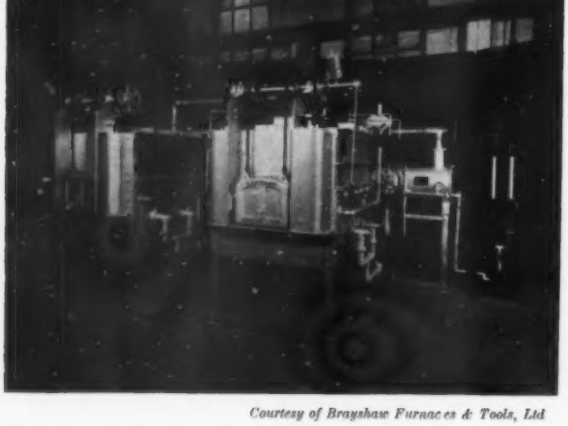
Fig. 19.—Vertical loading bright annealing furnace for copper coils.

Courtesy of Birlec, Ltd.

Fig. 20.—A gas carburising furnace used on gear transmission units.

Carburising

Many components, in all sections of engineering, are required to resist wear, but must also have ample toughness to withstand other service conditions: for such purposes casehardening, which preserves the tough core, may be adopted. The carburising medium used may be either solid, liquid or gaseous. Solid carburising compounds have been used since the inception of the process, and they continue to be applied to a greater extent than other media, but appreciable progress has been made in the use of both liquid and gaseous media, to which reference has been made in previous reviews. Many batteries of furnaces, using liquid carburisers, have been installed in the production lines in large works, furnaces by Kasenit, Ltd., being a typical example, but reference to salt baths will be considered later in this review.



Courtesy of Brayshaw Furnaces & Tools, Ltd

Fig. 21.—High temperature hardening and preheating plant with inert gas producer equipment.

Suitable gas carburising atmospheres have been developed, ranging from purified town's gas to a straight mixture of air and propane. In some cases, as in the Homocarb furnace designed by the Leeds and Northrup Company, and built in this country by the Integra Co., Ltd., a rich hydrocarbon oil is dripped on to a plate inside the furnace chamber where it "cracks" and the gas is carried over the charge by forced circulation, induced by a fan. In this furnace the drip-feed of hydrocarbon oil is controlled, the whole equipment being completely integrated, and not only is the load heated uniformly in a carburising atmosphere of the required consistency, but at the end of the soak it is cooled uniformly until it is ready for transfer to a cooling unit or quench tank.

Many pit-type furnaces for gas carburising have been installed recently, and Fig. 20 shows an installation of two gas carburising furnaces and a vertical forced air circulation furnace for subsequent tempering. This installation is used on gear transmission units, two typical charges of which can be seen in the illustration. In this case carrier gas obtained from an endothermic atmosphere generator, enriched by controlled amounts of butane, provides the carburising medium. However, a number of furnaces has also been installed during the year equipped for the drip-feed atmosphere system.

Hardening and Tempering

Hardening and tempering furnaces, to a large extent, are standardised, but the installation shown in Fig. 21 is rather unusual. It is a high temperature hardening and preheating plant complete with inert gas producer equipment, designed for the treatment of magnets and similar work under controlled atmosphere conditions. The plant consists of (left) a high temperature muffle furnace fitted with box brick Carbofrax muffle, and (right) a preheating furnace with box brick muffle in Alfrax quality refractories. In the background is visible the inert gas producer unit, which is capable of providing the controlled atmosphere for both furnaces.

Heating of the high temperature furnace is effected by gas and air blast burners with water-cooled nozzles, the nozzles being fed by a full air/gas mixture from a self-proportioning injector burner, which maintains the correct proportion of air and gas over the full burner consumption range. The burners fire into passages under the floor of the muffle, alternately from each side; the products pass round the sides and arch of the muffle and are collected in a refractory-lined flue box before exhausting to atmosphere by a damper-controlled mild steel flue pipe. Water gauges are fitted on the burner nozzles on each side of the furnace to facilitate lighting and the maintenance of efficient combustion conditions. Each unit has a muffle $15\frac{3}{4}$ in. wide $\times$ $11\frac{5}{8}$ in. high $\times$ 29 in. long (inside dimensions), and both are fitted with rising and falling counter-balanced doors which are manually handled from one side of the furnace. Provision is made for a prepared atmosphere to be admitted in the back and at both sides of the door vestibule.

A recent addition to the tool room furnace range is that shown in Fig. 22. It is a twin-chamber high-speed steel heat treatment furnace having a total rating of 20 kW. Each chamber is 24 in. long $\times$ 12 in. wide $\times$ 6

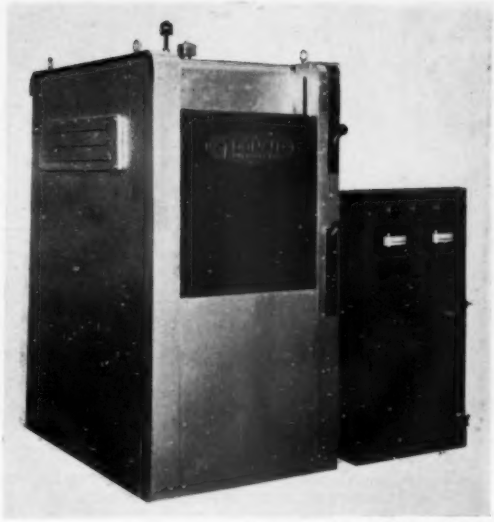
in. high, and has maximum temperatures of 1,000° C. and 1,400° C. for preheating and high temperature treatment, respectively. The elements for the lower temperature are 80/20 nickel-chrome material in heavy coil construction, supported on the walls, roof and hearth in special refractories, ensuring maximum radiation. Silit rods supported in the roof of the high temperature chamber are connected through a tap changing transformer to accommodate resistance adjustment and ensure close temperature control. Switchgear and temperature control instruments are housed on a compact panel.

Further progress has been made in the use of steam atmospheres in tempering furnaces and many plants have been installed which can turn out work that has superior resistance to wear, longer life, better machinability, and greater resistance to corrosion, as a result of steam atmosphere treatment. In the steam Homo method of the Leeds Northrup Co., equipment for which is built in this country by the Integra Co., Ltd., scale-free heat treating is provided for both ferrous and non-ferrous components at temperatures up to 620° C. When applied as a final operation to iron and steel, it imparts a blue-black oxide finish which gives the parts desirable qualities. Operation is simple. For ferrous parts the furnace is first brought to 370° C. with air atmosphere, then held at this temperature for half an hour while steam is injected to purge air from the work chamber. The load is then heated to soak temperature and held for the specified time, with steam flowing through the furnace. At the end of the soak, work is either air-cooled or quenched in soluble oil. For non-ferrous work the furnace may be purged as low as 200° C.

Several Birlec furnaces have also been installed during the year for steam tempering high-speed steel drills and other cutting tools. Their standard equipment for this application is an adaptation of the Birlec vertical forced air circulation furnace.

The heat treatment of high-speed steels and other tool steels is often carried out in a neutral atmosphere to protect them from scaling, and to prevent carburisation or de-carburisation. For this purpose the Efco-Lindberg charcoal generator has been developed, by which the neutral atmosphere is produced by passing air through a hot bed of charcoal. For hardening high-carbon, tool and high-speed steels without scale, carburisation or decarburisation, charcoal gas is claimed to be the most foolproof and dependable atmosphere, particularly for such materials as molybdenum high-speed steels, silico-manganese, spring steels, and high-carbon and high-chromium steels. It is also applied for the bright hardening of high-carbon spring steel parts and stampings, for annealing and normalising high-carbon steels, for the copper and silver brazing of high-carbon or tool steels, and for sintering medium or high-carbon powder metals.

The continuous heat treatment of very small components often needs specially designed furnaces. An ingenious example of such an installation is that shown in Fig. 23, which depicts the first of a battery of a dozen vibrator-tube furnaces designed to replace batch type equipment. The chamber consists of a solid-drawn heat-resisting tube held centrally in an outer tube, the annular space being filled with insulating materials. Allowance is made for the expansion of the inner tube at the entry end of the equipment ; the exit end leads direct to a quench chute, the bottom of which is below

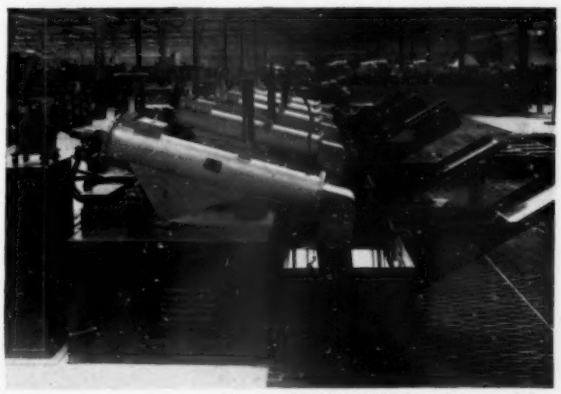


Courtesy of McDonald Furnaces, Ltd.

Fig. 22.—A twin-chambered tool room furnace.

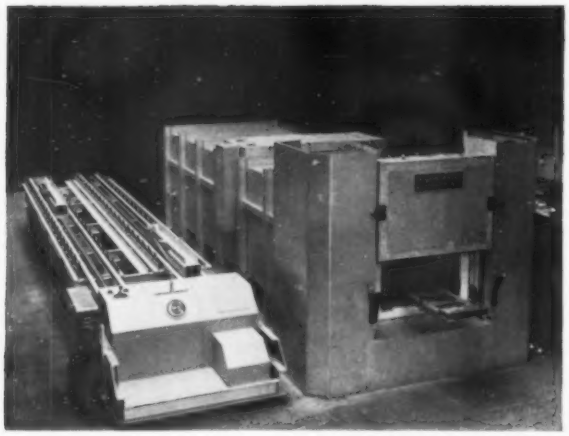
the oil level of the quench tank. One end of the equipment is suspended in such a way that the angle of the tube can be adjusted to vary the feed rates. A Syntron vibrator fixed below the furnace casing provides the energy to cause the components being treated to pass through the tube, and variation of the vibrator also varies the feed rate. Temperature control is provided by means of electronic controllers. At a temperature of 800–850° C., each furnace has an output of approximately 15 lb./hr. With this installation, one operator can attend to four furnaces, the work being limited to feeding the hoppers and removing finished work from the quench tank.

An interesting dual-purpose furnace unit is shown in Fig. 24, which is designed for high or low temperature operation. As is well known, at temperatures below approximately 650–700° C. some form of forced air circulation is desirable to ensure uniformity, and to speed up heat transfer from the resistance elements to the charge. In this design, forced convection is obtained by means of a heat-resisting steel removable duct, fitted



Courtesy of Wild-Barfield Electric Furnaces, Ltd.

Fig. 23.—An installation of tube furnaces for continuous hardening of small components.



Courtesy of G.W.B. Furnaces, Ltd.

Fig. 24.—A dual-purpose electric resistance furnace equipped with charging skip.

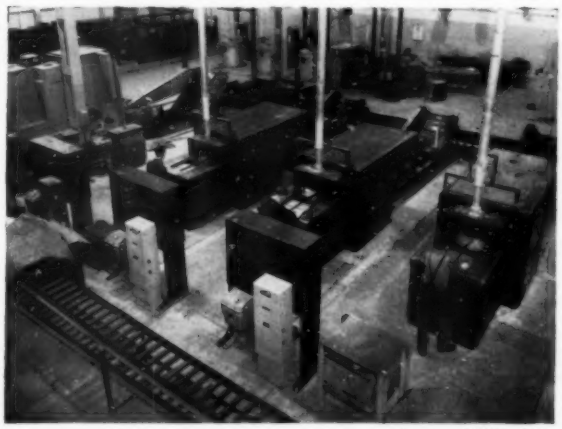
with rollers running in cast heat-resisting tracks set in the hearth brickwork. When working in the lower temperature range, a double entry fan, situated in a separate insulated casing at the rear of the furnace, apart from the working chamber, is set in operation. Air is thus forced over the strip heating elements, supported on hooks along the sidewalls and in the roof, and through the charge carried on a skip within the removable duct. At higher temperatures, where radiation is the prime factor in heat transmission, the duct is removed and the fan does not operate. The furnace is equipped with an all-electric charging equipment, which not only charges and discharges the load, but is also arranged to pull out the duct and re-insert it when necessary. During the operation, the charging machine traverses in front of the furnace ; the reason for its position as shown in the illustration is that the whole installation is for export to India and has just been trial erected in the G.W.B. works.

One aspect of heat treatment, which can be mentioned here, is the provision of a suitable protective atmosphere to prevent oxidation and to obtain a " bright " or " clean " finish on the material being processed. In industrialised countries, town's gas provides a convenient multi-purpose atmosphere, while natural gas is often used, when obtainable ; both these gases, and others that may be used, normally require to be passed through a suitable preparation plant before being introduced into the furnace chamber. In countries, such as India, now going through a phase of industrial expansion, there are rarely any gas supplies which can be tapped, so use often has to be made of bottled gas, which is an expensive item. Kerosene is usually available in such countries, and so G.W.B. have developed a protective atmosphere plant using this fuel. The different requirements for the bright annealing of copper and steel, respectively, are catered for at a running cost which compares favourably with burnt town's gas in the United Kingdom.

Mention has previously been made of an ingenious design of vibrator furnace ; another type for continuous bright hardening of small steel parts is shown in Fig. 25 and will be more familiar to readers. This installation comprises three 45 kW 18 in. furnaces, which are all used for the continuous hardening of high-carbon alloy steel components weighing about 1 lb. each. An interesting feature of this size of furnace is that the shaker hearth is made up of two 9 in. wide strips, bolted together at the charge end ; this arrangement minimises distortion of the hearth plate. In the background of the illustration is a 90 kW, 24 in. wide cast link belt conveyor furnace for hardening larger components. The protective atmosphere for all four furnaces is derived from one 1,500 cu. ft./hr. and two 1,000 cu. ft./hr. endothermic atmosphere generators.

Nitriding

An unusual hardness is imparted to the surface of certain steel components in suitable furnaces when ammonia gas is used as an atmosphere at appropriate

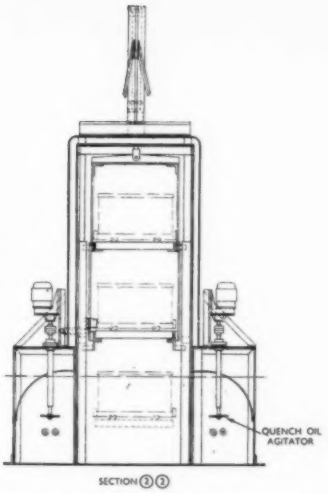


Courtesy of Birlec, Ltd.

Fig. 25.—A battery of continuous bright hardening shaker furnaces.

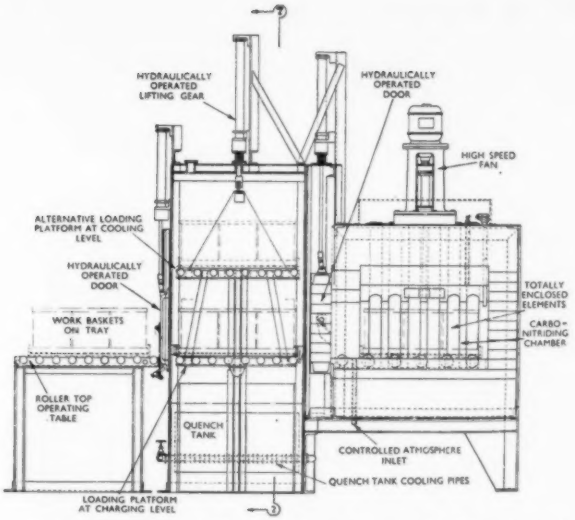
temperatures. This is the well known nitriding process for which a number of firms manufacture special furnaces. The process has been applied for many years and continues to enjoy a popular appeal in a wide range of applications. In recent years, however, a process known as carbonitriding has been developed, which combines both carburising and nitriding. As with straight carburising, the concentration of the hardening elements, whether nitrogen or carbon and nitrogen, is highest at the surface of the steel and decreases progressively towards the core, hardening of the case being effected by either a separate preheat and quench or, preferably, by a direct quench.

Vertical or horizontal batch type furnaces are usually employed for these processes, and details of a new horizontal design are shown in Fig. 26. This furnace enables the complete process, including oil quench or, alternatively, cooling in the carbonitriding atmosphere, to be carried out without exposing the charge to air, and without cooling down the furnace chamber. In addition to the heating chamber, the furnace has a purging section, an oil quench tank and a cooling chamber. The doors and quench gear are operated hydraulically. Both the cooling chamber and the quench tank are water cooled, and the latter is fitted with agitating propellers. The heating chamber has totally enclosed tubular heating elements. Alternative loading platforms allow cooling or quenching to be carried out, whilst another charge is in the carbonitriding chamber. A



Courtesy of The General Electric Co., Ltd.

Fig. 26.—Details of a new furnace for surface hardening steels by the carbonitriding process.



furnace of this design, to take a batch of parts weighing 250–300 lb. would have an overall length, including charging table, of 13 ft. and a height of $11\frac{3}{4}$ ft. It would accommodate three baskets on a carrier tray 36 in. long × 24 in. wide × 15 in. high.

New nitriding plant has recently been installed at the Coventry works of Jaguar Cars, Ltd., where it is used for surface hardening crankshafts. The installation, shown in Fig. 27, comprises a 56 kW pit furnace with fully-automatic temperature control and recording gear, switchgear, ammonia flow panel, dissociation-testing cubicle, and two heat resisting steel nitriding containers equipped with fans. The crankshafts are suspended from a casting carried by suspension bars attached to the lid of a container and sealed with the envelope. The container is purged with the nitriding atmosphere before being placed in the furnace, the temperature of which is controlled at 500° C. The depth of hardened case obtained depends upon the time the charge is held at temperature. A total heating cycle takes from 60 to 70 hours, but during this period the plant requires very little supervision.

Courtesy of The General Electric Co., Ltd.

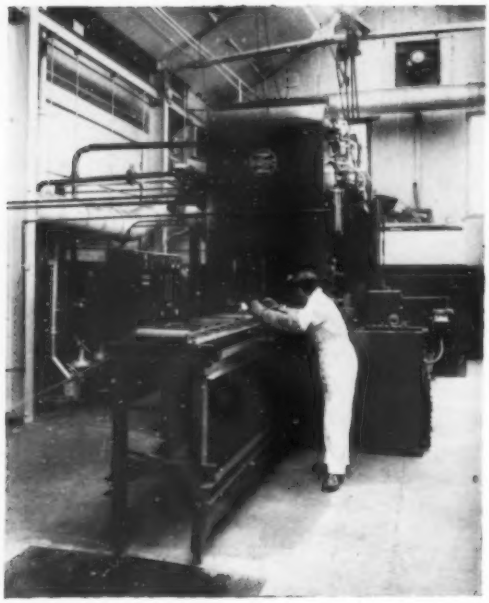
Fig. 27.—Nitriding plant recently installed for surface hardening crankshafts.

It is claimed that the speed and control of treatment by the carbonitriding process has increased the number of equipments in use applying it. One such furnace is shown in Fig. 28. It is of the rotary-drum type and is used for a variety of small components. The output is a function of the case depth required and of the type of work; in this particular instance, it is being used on small components to give a case depth between 0·003 and 0·007 in. with an output of 100–150 lb./hr., the temperature of treatment being 850° C. This equipment is distinctive in that raw town's gas is fed direct, without treatment, to a junction at the furnace where it is mixed with ammonia from cylinders before entering the chamber. This is a patented Wild-Barfield process, and the fact that no town's gas plant is necessary reduces the capital outlay involved, without affecting the efficiency of the treatment.

An interesting advance in the design of carbonitriding furnaces is that furnished by the Efco-Lindberg equipment for this process. It is a gas-fired, vertical radiant tube furnace with a built-in quench tank. The work to be processed enters a vestibule, immediately above the

Courtesy of Wild-Barfield Electric Furnaces, Ltd.

Fig. 28.—A rotary drum furnace for carbonitriding small components.



Courtesy of Birlec, Ltd.

Fig. 29.—A general purpose furnace designed for carbonitriding or dry-cyaniding.

quench tank, where it is preheated before passing to the heating chamber proper, to avoid drastic temperature change, during which time the work is completely purged. The loading table and a 2-deck elevator are equipped with conveyor rollers to facilitate loading. With an Efco endothermic atmosphere generator coupled to this furnace, in addition to carbonitriding it may be used for carburising, annealing, hardening, carbon restoration, and other more delicate operations. Usually 10–20% anhydrous ammonia gas and 5–10% town's gas are added to the generator gas for carbonitriding, but changing the percentage of ammonia and hydrocarbon gases enables the nitrogen and carbon content to be varied. An even and constant circulation of the furnace atmosphere is obtained by a fan mounted below the furnace, which assures uniformity of case depth and temperature. The heating chambers in this furnace are 24 in. wide × 36 in. long × 18 in. high.

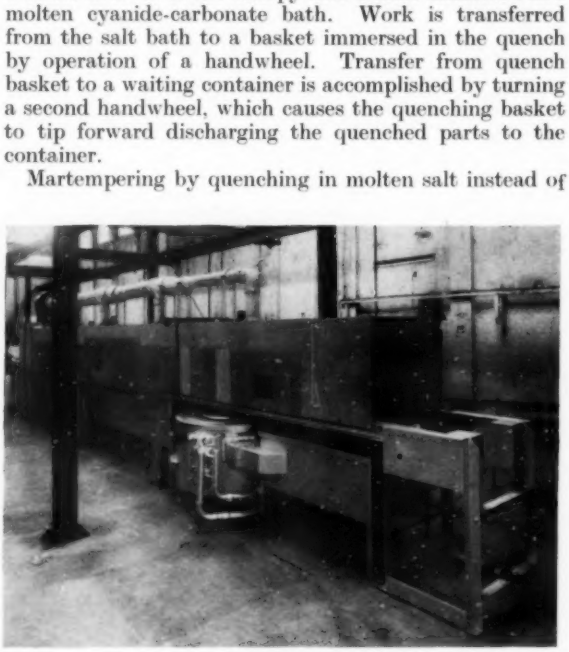
During the year under review, the first British-built Birlec-Dow furnace has been installed for the carbonitriding process. This furnace, shown in Fig. 29, is also designed to enable heating and cooling or quenching to take place without exposure to the air. This is made possible by the use of a vestibule equipped with vertical doors in front of the heating chamber. A charge can, therefore, be pulled from the furnace chamber into the vestibule for cooling and/or for transfer to the oil quench tank beneath, without opening the outside door. In this case heating is by vertical gas-fired radiant tubes, and an interesting feature of their design is that each incorporates its own endothermic atmosphere generator. Not only does this design achieve economy in fuel consumption, but floor space of a separate generator is saved. Apart from carbonitriding, this furnace is suitable for such controlled atmosphere applications as reheating and bright hardening.

Salt Baths

The protection of surfaces from decarburisation and scale can be effected by the use of salt baths, a technique which has advantages in speed and accuracy over many methods, and which continues to make progress in spite of competition from the newer gaseous processes. The basic advantages of salt baths are simplicity of operation, regularly reproducible results and excellent finish, and the labour involved needs only the minimum of technical skill. During the past year, more attention has been given to designing partially or totally enclosed plants with a view to collecting fume from the molten bath and so preventing it from passing into the atmosphere of the shop.

Typical of recent designs is the plant shown in Fig. 30; it shows the front view of a Cassel automatic plant now in use to supplement the output of a similar furnace installed earlier for austempering typewriter parts. Both austenitising and quenching/transforming are done in salt, the parts passing automatically through all operations, i.e., preheating, austenitising, austempering, washing and drying. Similar furnaces have recently been constructed for case-hardening automobile parts, using a cyanide-carbonate bath for carburising, and a bath containing cyanide for reheating. The sequence of operations is: preheat, carburise, oil quench, wash, preheat, reheat for hardening, oil or water quench, temper, alkali wash. The parts are loaded at one end of the plant, on jigs or wires, and leave the other finished, being carried through all stages automatically. A smaller and cheaper batch type furnace for casehardening small parts is illustrated in Fig. 31. This is a hand-operated, gas-fired Cassel furnace 10½ × 15 in. Work is preheated in scoops in the chamber at the right of the illustration; the operator then transfers the work through a chute in front of the canopy into a ladle immersed in a molten cyanide-carbonate bath. Work is transferred from the salt bath to a basket immersed in the quench by operation of a handwheel. Transfer from quench basket to a waiting container is accomplished by turning a second handwheel, which causes the quenching basket to tip forward discharging the quenched parts to the container.

Martempering by quenching in molten salt instead of



Courtesy of Imperial Chemical Industries, Ltd.

Fig. 30.—A 'Cassel' automatic plant in use for austempering typewriter parts.

oil is claimed to reduce distortion, and is increasing in favour on that account. Larger martempering furnaces have lately been built to handle large dies. Such a furnace is shown in Fig. 32. It is fitted with a salt separator to remove the salt carried over on quenched parts from the austenitising bath. An improved type of belt-driven propeller agitator is used to circulate the quenching salt, thus giving an efficient quench, equalling that achieved by oil quenching.

The use of salt baths for hardening high-speed steel and hot-die steel parts is well known, and is often a preferred method of protection of the parts from scale and decarburisation during treatment.

Further progress has been made in the introduction of the electrically-heated salt bath, such as the Efco-Ajax-Hultgren equipment which is heated by a pair of electrodes immersed in the salt. The patented grouping and design of these electrodes produces a strong circulation of the salt by the electro-magnetic force generated round each pair and, in addition to providing a faster rate of heating, it is claimed that a more uniform temperature distribution is assured.

Induction Heating

The equipment used for induction heating differs fundamentally from the conventional plant used for heat treatment, but it carries out a metallurgical function that might otherwise be carried out in a furnace: it is important, therefore, that some reference should be made to progress in this field.

A considerable amount of research and experimental work has been carried out during the past year by several heat treatment plant firms, the results of which have led to the production of equipment now being supplied to several companies in this country and abroad. Three interesting new applications have proved successful, brief reference to which can be made here.

The general principle of high frequency induction heating for surface hardening is well known, but the Electric Furnace Co., Ltd., have developed a special inductor which enables the same production to be achieved with an equipment of smaller capacity and lower capital cost. This inductor is a laminated iron-cored unit, by means of which the high frequency current is focussed on a relatively small area, and the work piece

Courtesy of Imperial Chemical Industries, Ltd.

Fig. 31.—A batch type furnace for casehardening small parts in salt.

Courtesy of Imperial Chemical Industries, Ltd.

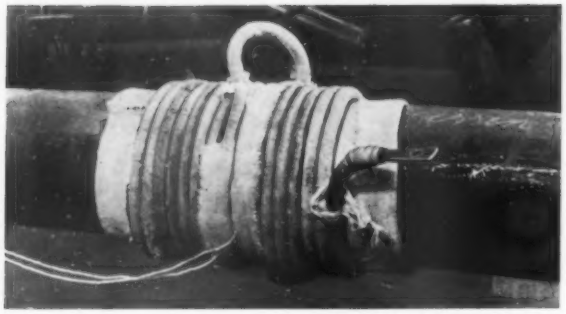
Fig. 32.—New equipment for martempering by quenching in molten salt.

to be heated is rotated under this special inductor, or, in the case of flat surfaces, passed underneath it. The advantages of this method are that an even and thin depth of case can be satisfactorily obtained and, where this case is acceptable, equipment of small power source can be used instead of larger and more expensive plant.

Another application of high frequency induction heating is the pre-heating before welding, and subsequent stress relieving, of large fabricated bodies. This process has been developed especially in connection with turbine rotors, large pressure vessels and heavy fabricated structures where a series of castings are welded together to form the final assembly. The basic principle of this process is to use standard high frequency motor generator equipment, but instead of the usual rigid water-cooled inductor coil, flexible asbestos covered cables made of a special non-oxidising alloy are wound around the surface to be heated, as in Fig. 33. These are then covered by a heavy heat insulating asbestos blanket and a slow soaking heat is applied. The same method is used for raising the temperature of damaged parts of castings as a preliminary to repairing them by the " burning on " process.

It is interesting to note that, in spite of extensive tests with various frequencies from 50 to 10,000 cycles, 2-3,000 cycles has proved to be the most effective for this stress relieving application, as this frequency gives the optimum heat penetration in view of the physical difficulties of inducing sufficient power at lower frequencies into a relatively small area.

In the low frequency range, 50 cycle equipment has been built and supplied to several leading British firms, as well as abroad, for heating non-ferrous billets for extrusion. In this case ordinary mains power is used, thus avoiding the cost of a frequency converter, and billets of diameters of 3 in. up to 12 or 15 in. can be heated to the desired temperature. A special feature of

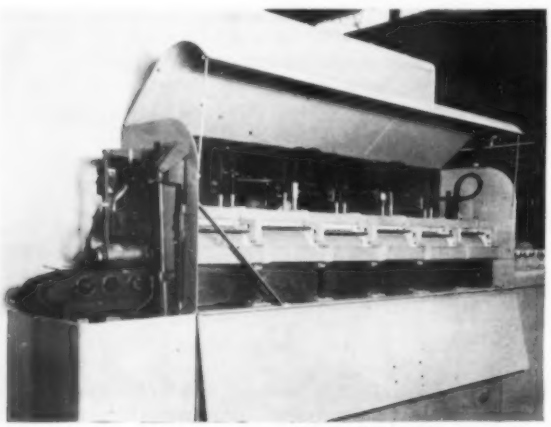


Courtesy of Electric Furnace Co., Ltd.

Fig. 33.—Flexible asbestos covered cables for induction heating of large fabricated bodies before welding and for subsequent stress relieving.

this mains frequency heater is the fact that random lengths of billet can be fed into the coil one after the other and uniform temperature throughout the cross-section and length of the billet is assured. The press operator is in sole control of the equipment. The floor space required, the labour necessary to operate them and the working conditions around induction heaters, compare advantageously with standard gas-fired or electric resistance furnaces for the same purpose. The equipment shown in Fig. 34, for instance, is suitable for heating all non-ferrous metals, and is also used in conjunction with high frequency equipment for heating steel billets for forging purposes. In this case, the billets are brought up to around the change point using 50 cycle power and then passed immediately into another inductor coil, through which high frequency power is introduced to bring them up to the required forging temperature. By reducing the size of the frequency converter required, the capital cost of such a plant is lowered, and the overall efficiency of the mains frequency side of the equipment is higher than that of the high frequency part. The rating of the equipment shown in Fig. 34 is 150 kW for heating 1,250 lb./hr. of 8 in. diameter aluminium billets to a temperature of 550° C.

The heating of dies for extrusion and other purposes can also be carried out and, in this case, again, on the size of the die and the time available to heat it

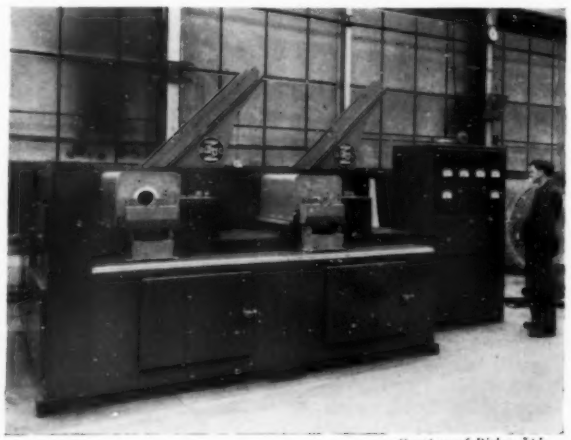


Courtesy of Electric Furnace Co., Ltd.

Fig. 34.—Induction equipment for heating 8 in. diameter aluminium billets to a temperature of 550° C.

to a temperature in the range 400–500° C., will depend whether high or low frequency power is used. In this application, the irregular shape of the die holders and dies may make the heating equipment less efficient, where high frequency power and a water-cooled coil is used. With the use of flexible cables, however, this difficulty can be overcome and, if a slow heating cycle is acceptable, mains frequency can be used.

A high frequency induction heater unit for heating steel forging billets to 1,200° C. is shown in Fig. 35. Power is supplied from a motor-alternator unit and interchangeable heating coils are provided to deal with billets ranging from $1\frac{1}{2}$ to $2\frac{1}{2}$ in. diameter. The machine is rated for an output of approximately $\frac{1}{2}$ ton/hr. Maximum billet length is $4\frac{1}{2}$ in. and the steel is fed from two sloping magazines from which the billets are pushed automatically into the horizontal coils by a hydraulic mechanism. A moving grab device, at the discharge end of the coil, withdraws each billet quickly and



Courtesy of Birlec, Ltd.

Fig. 35.—High frequency induction heater for steel forging billets.

discharges it on to a conveyor leading to the forging press.

Several high frequency units have been supplied to automobile manufacturers, designed, in some cases, for the progressive surface hardening of such parts as rocker-shafts, gearbox selector shafts, etc. Others, such as that shown in Fig. 36, are designed for annealing. The example illustrated is used for annealing the threaded ends of carburised shackle pins to prevent chipping of the threads on assembly. On the other hand, low frequency equipment is in use for heating automobile starter gears for shrinking onto the engine flywheel. The equipment operates at 50 cycles, and a heating time of the order of 20 secs. is obtained, being regulated by pre-set process timer.

Fig. 37 shows a high frequency unit for surface hardening tank track pins which has been designed and installed at the Cardiff works of Curran Steels, Ltd. The pins are of carbon steel, and range from $\frac{1}{2}$ to 1 in. diameter: they must be hardened to depths ranging from 0·025 to 0·050 in. with a minimum hardness of 54 Rockwell C, and within close limits of eccentricity. The machine comprises a 25 kW high frequency generator, automatic bar-handling gear, heat exchanger for cooling the quenching medium and a voltage stabiliser.

Devices for protecting the machine against possible misuse are incorporated, and once set up the equipment can be tended by unskilled labour.

Brazing Furnaces

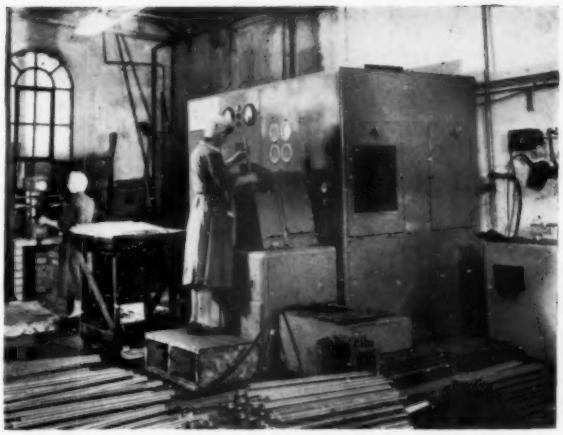
Since the introduction of heat treatment furnaces for brazing there has been a growing interest in their use and further developments in the process have been made in recent years. Metals which are not easily oxidised, such as carbon steel, may be brazed in protective atmospheres such as burnt town's gas and burnt ammonia, using filler metals such as copper or copper alloys. During the past year or two the high temperature processing of stainless steel components has become of increasing interest, in the brazing of which it is necessary to maintain close control over the quality of the atmosphere for

Courtesy of Birlec, Ltd.

Fig. 36.—High frequency induction heater for annealing the threaded ends of carburised shackle pins.

traces of oxygen, since water vapour or carbon dioxide will form an oxide film on the surface of the components and prevent a sound joint being made. Similar considerations apply when the brazing alloy itself is readily oxidised, as with certain high temperature brazing alloys. In the new technique, a very dry hydrogen atmosphere is used and treatment is carried out in a sealed container.

A vertical cylindrical furnace, designed for this process is shown in Fig. 38. The assemblies are loaded on a base casting and sealed within the furnace pot, which is then immediately purged with the dry hydrogen atmosphere. If considered desirable, the pot may first be purged with nitrogen. The pot is placed in the furnace and the charge brought to the required temperature and held at that temperature for 10–30 minutes, depending on the brazing alloy being used. The pot is then removed from the furnace and the charge cooled in the protective atmosphere. Components made by this new technique, using a high temperature brazing alloy, are shown on the right of the illustration.

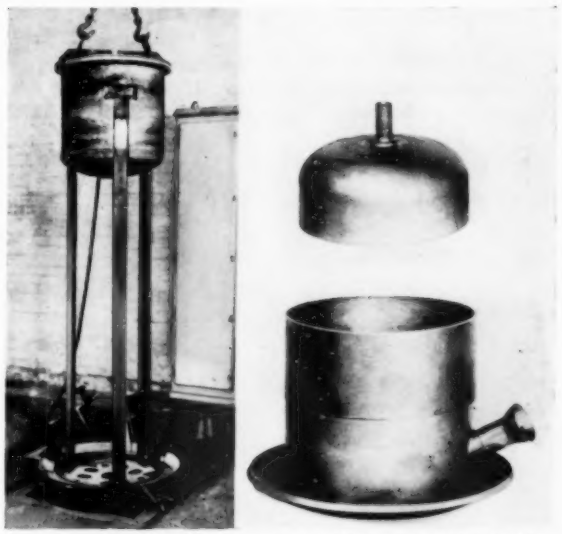


Courtesy of The General Electric Co., Ltd.

Fig. 37.—High frequency induction furnace for surface hardening tank track pins.

Another equipment expressly designed for stainless steels by Birlec Ltd., is an 18 kW pit-type furnace with gas-tight charge container about 1 ft. in diameter and just over 2 ft. deep. Two containers are provided with each furnace so that one charge can be cooled in the atmosphere whilst another is being heated. Both containers are provided with insulated plugs through which the atmosphere connections are led.

Furnace brazing methods which effect considerable economies can now be extended to aluminium, and greatly increase the potential use of this metal for numerous engineering and aircraft fabrications, etc., where ease of working, light weight and good heat conductivity are advantageous. The furnace illustrated in Fig. 39 has been specially designed for this application. It is a furnace of the horizontal, forced air circulation, batch-loading type, with a special charging trolley for quick loading and unloading. Trays and supports are



Courtesy of The General Electric Co., Ltd.

Fig. 38.—A new brazing technique involving the use of a very dry hydrogen atmosphere.

Courtesy of Barlow-Whitney, Ltd.

Fig. 39.—Electrically heated horizontal forced air circulating furnace for aluminium brazing.

Courtesy of Wild-Barfield Electric Furnaces, Ltd.

Fig. 40.—An installation of heat treatment equipment at a well-known technical college.

supplied to suit the components to be handled. Furnaces of this type are built to specific requirements, the one illustrated having a rating of 90 kW and a heating chamber 9 ft. long × 18 in. wide × 12 in. high.

These furnaces feature rapid heat recovery and the close temperature regulation essential for this process, which is carried out at a temperature approaching the melting point of aluminium. Control is so arranged that when front and back temperatures are equal, and with the brazing temperature at about 625° C., the process timer goes into operation and automatically shuts off the furnace and rings an alarm bell at the end of the pre-set time—usually about 3–5 minutes.

The use of high frequency induction heating for this purpose has also developed, and a Birlec installation of this kind for brazing carbide tips to turning tools, rated at 5 kW, incorporates a specially shaped heating inductor, operating at a safe low voltage. Inductors can be readily interchanged to deal with different types and sizes of tools. The equipment referred to is capable of dealing with tools about 1½ in. square.

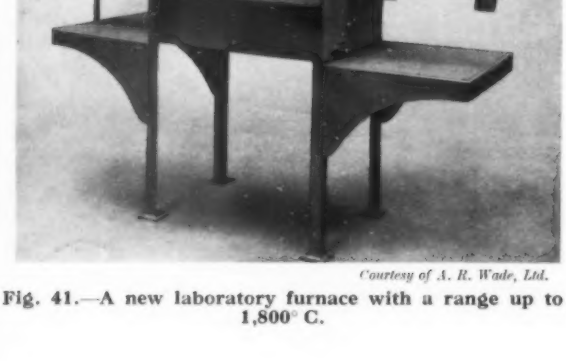
Equipment in Technical Colleges

An indication of the growing importance of heat treatment processes is the increasing number of technical schools and colleges where heat treatment is being given serious consideration. Many new equipments have been installed for this purpose. Part of such an installation is shown in Fig. 40, by which full-scale production processes can be simulated. The batch furnace on the left is suitable for hardening, normalising, box carburising, etc., and is completely self-contained, having a built-in atmosphere control system in addition to the normal temperature control and indicating instruments. The equipment includes three high frequency units and a small salt bath.

Another recent installation is that at the National Foundry College, Wolverhampton, where the heat treatment room is equipped with two 10 kW and one 20 kW Birlec batch furnaces for general applications. In addition, this room contains a vertical forced air circulation tempering furnace.

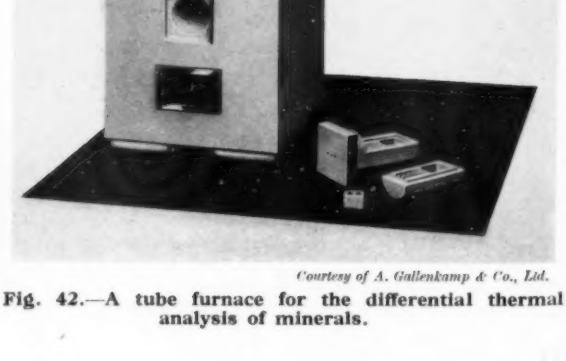
Laboratory Furnaces

Metallurgical laboratories are generally well equipped for carrying out the various heat treatment processes, but special equipment is sometimes necessary. Recently designed is a laboratory furnace with a temperature range up to 1,800° C., which can be controlled between fine limits of temperature and—what is more important



Courtesy of A. R. Wade, Ltd.

Fig. 41.—A new laboratory furnace with a range up to 1,800° C.



Courtesy of A. Gallenkamp & Co., Ltd.

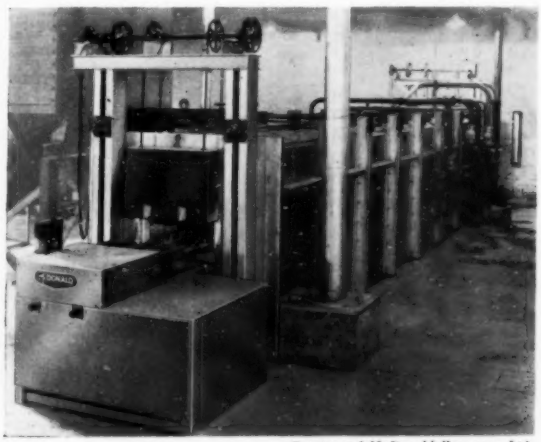
Fig. 42.—A tube furnace for the differential thermal analysis of minerals.

—its rate of temperature rise can be so controlled as to give a characteristic of almost any desired shape. This furnace, shown in Fig. 41, has wide applications, such as the testing of refractory materials, as well as metallurgical treatments associated with high temperature metals and alloys, particularly the carbides.

A recent introduction by A. Gallenkamp & Co., Ltd., is a tube furnace for the differential thermal analysis of minerals shown in Fig. 42. This electrically heated furnace consists of an Asbestolite case 8 × 8 × 10 in. high and a refractory tube $1\frac{3}{4}$ in. bore, open at both ends, wound with high grade wire. It can accommodate two heating blocks and the case has a recess at each side to receive the square flanges of the heating blocks. The loading is chosen to enable the temperature to be increased at 10° C./min. up to 1,000° C., i.e. from room temperature to 1,000° C. in 100 minutes. The maximum temperature is 1,000° C.

Special Purpose Furnaces

Recently installed is a continuous furnace specially designed for the indirect heating of powdered material contained in shallow trays. It is a pusher type muffle



Courtesy of McDonald Furnaces, Ltd.

Fig. 43.—A pusher type muffle furnace for the continuous indirect heating of powdered material.

furnace and is fired by clean producer gas. The burner equipment is designed to give maximum flexibility to obtain the precise time-temperature cycle required for processing the charge material, together with an evenness of temperature distribution throughout the chamber section. The trays are accommodated on support shoes located and guided in skid rails extending the furnace length. The shoes conveying the charge are transported through the furnace by means of a mechanically-operated charging machine, and are specially shaped to transmit the pushing force without any external load on the tray containers.

To ensure non-contamination of the charge material by the combustion products, the furnace is provided with a specially designed refractory muffle heating chamber, composed of radiant heating panel-type brick-work having tongue-and-groove jointing to form a gas-tight construction and incorporating a fume extraction flue, with damper control, situated near the charging end of the furnace. The 40 ft. length of furnace is divided into two firing zones, the zone nearer the discharge end being

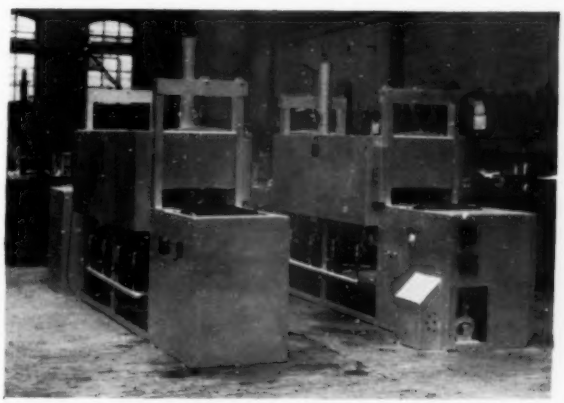
Courtesy of A. R. Wade, Ltd.

Fig. 44.—A hump-back type of furnace for sintering or annealing in powder metallurgy.

fitted with automatic temperature control gear, and a pre-heating section utilising the waste heat from the exhaust gases. The burner distribution is arranged each side of the furnace for underfiring the muffle hearth on to deflection piers directing the combustion products around the muffle side brickwork and over the roof arch. The waste gases are drawn off through damper-controlled ports below the muffle hearth at the charging end of the furnace to permit efficient gas circulation for the heat transference to the pre-heating length of the muffle. This furnace, a duplicate of which is now being installed at the same works to handle twice the original output, is shown in Fig. 43.

Of great interest in the powder metallurgy field for sintering and for annealing is the furnace shown in Fig. 44. It is of the hump-back design, and the advantages claimed for it are low atmosphere consumption and the absence of burn-off flames. This hump-back design is not limited in its application; it is in use in a variety of industries and several furnaces have been supplied to a large radio valve manufacturer for de-gassing purposes.

Another installation recently developed is a continuous conveyor oven for shell moulding, a process on which considerable progress has been made in this country. Among the advantages of the process are: superior finish,



Courtesy of The Dawson & Mason Gas Plant Co., Ltd.

Fig. 45.—Continuous conveyor ovens for shell moulds.

closer tolerances, ease of casting thin sections, lowered surface chilling of metals, and reduced after-machining costs. The many factors that influence production by this process have been investigated. One of these is that of the oven temperature for setting the moulding material, which contains a percentage of phenolformaldehyde resin. The oven shown in Fig. 45 has been designed and built especially for baking and curing of pattern and invested plates up to a maximum weight of 50 lb.

The ovens illustrated each have 16 in. wide conveyor belts with oven lengths of 6 ft. from door to door, incorporating variable speed for the conveyor drive, which allows the time of heating up to be adjusted to suit the size and weight of plate. Each oven will handle between 3 and 4 plates each minute. Operating temperatures are about 200° C. and 300–400° C. respectively, and special aerated gas burners are used to give very uniform heating.

New and Revised British Standards

ARC WELDING PLANT AND EQUIPMENT (B.S.638 : 1954) PRICE 7s. 6d.

THIS revised British Standard deals with both D.C. and A.C. equipment and includes requirements for heavy duty multiple arc A.C. equipment for heavy constructional work, which was previously dealt with in the war emergency B.S.1071. The basis of rating used in the two previous issues of this British Standard has been retained and the only major modification is the introduction of maximum hand welding current which, together with a definition of arcing time factor, should enable the user to select with greater accuracy the correct capacity of welding plant for a given duty. Provision is made for a type of single operator plant, which, when operated at a lower arcing time factor than that assumed in the standard rating, can be used to supply currents in excess of the maximum continuous hand welding current. Such plant is required to be fitted with a warning plate stating the value of this maximum current. Part 4, which deals with multiple arc transformer welding plant for heavy duty, follows closely B.S.1071 : 1943 except that the standard open-circuit secondary voltage has been reduced from 100 to 90. As a result, the welding current per phase has been raised from 300 to 350 amp. In addition to the rating of welding plant the specification includes requirements for welding cables, plugs and sockets, electrode holders, return current clamps, items associated with personnel protection and paralleling boxes and devices for use with heavy duty plant.

INDUSTRIAL EYE-PROTECTORS FOR OPERATIONS OTHER THAN WELDING (B.S.2092 : 1954) PRICE 4s.

THIS British Standard specifies the essential requirements for eye-protectors suitable for common industrial operations : it extends and supersedes B.S.955 : 1941, 'Spectacle Type Goggles for Protection against Flying Particles.' It does not deal with protection against harmful radiation which is covered separately in B.S.679 'Protective Filters for Use in Welding and Similar Industrial Operations,' in B.S.1542 'Equipment for Eye and Face Protection during Welding,' and in B.S.1729 'Green Protective Spectacles and Screens for Steelworks Operatives.' Protection from glare is not covered and may be an additional requirement, nor is reference made to face shields or screens.

The standard covers both heavy duty eye-protectors and light duty eye-protectors, the essential difference between the two being the requirements of the impact specified in Appendix B. Attention is drawn to the fact that corrective safety lenses are available if required. Care has been taken to avoid any hindrance to the free development of equipment, and this standard will be revised whenever progress makes this necessary.

The following types are covered : industrial spectacles, wire basket goggles, cup-type goggles, box-type goggles, chemical goggles, gas-tight goggles, one-piece eye-protectors, and dust-tight goggles. The standard specifies requirements for essential points of design and manufacture, the materials used, and the mechanical strength of lenses and complete protectors : methods of test are included. The standard also covers lenses for eye-protectors supplied either assembled or separately.

GLOSSARY OF TERMS RELATING TO IRON AND STEEL (B.S. 2094, PARTS 1–6 : 1954) PRICE : PART 1, 6s. ; PARTS 2–6, 2s. 6d.

PART 1 : GENERAL METALLURGICAL, HEAT TREATMENT AND TESTING TERMS
PART 2 : STEEL MAKING
PART 3 : HOT ROLLED STEEL PRODUCTS (EXCLUDING SHEET, STRIP AND TUBES)
PART 4 : STEEL SHEET AND STRIP
PART 5 : BRIGHT STEEL BAR AND STEEL WIRE
PART 6 : FORGINGS AND DROP FORGINGS

THE glossary has been prepared to establish as far as possible uniformity in the interpretation of the numerous terms in current use. The scope has been limited to those terms in general use in the different producing sections of the iron and steel industry. Terms dealing with the various applications of iron and steel products, e.g., in welding and electrical engineering are covered in other British Standard glossaries. Part 1, covering general metallurgical heat treatment and testing terms, is complementary to the other parts of the glossary which deal with particular sections of the industry.

CHILLED IRON SHOT AND GRIT (B.S.2451 : 1954). PRICE 2s.

THE primary purpose of this standard is to assist in overcoming the difficulties which have been experienced by users in obtaining uniform grades and sizes of chilled iron shot and grit for use in shot blasting and kindred applications. The main object in preparing the standard has, therefore, been concerned with the separation and sizing of the chilled shot and grit and designating grade and size numbers. It has also been considered desirable to include requirements for hardness.

The Institution desires to point out that the term "steel shot and grit," which is commonly used in certain sections of the trade, is a misnomer and strongly recommends that its use be discontinued. The correct term is "chilled iron shot and grit." The grades and sizes of chilled iron shot and grit covered by this standard have been designated 7, 8, 9, 10, 12, 15, 18, 22, 30 and 40.

Copies of these British Standards are available from the British Standards Institution, British Standards House, 2, Park Street, London, W.1.

NEWS AND ANNOUNCEMENTS

Institution of Mining and Metallurgy

THE Council of the Institution of Mining and Metallurgy have announced the following awards :—

The Gold Medal of the Institution has been awarded to MR. ESSINGTON LEWIS, C.H., President of the Fifth Empire Mining and Metallurgical Congress, in recognition of his long and distinguished services to the Mining and Metallurgical Industries of Australia.

Honorary Membership of the Institution has been conferred on MR. T. PRYOR, D.S.O., in recognition of his services to the Institution and to mining education.

The Consolidated Gold Fields of South Africa, Ltd., Gold Medal for 1953 has been awarded to DR. J. S. WEBB for his work on the development of geochemical prospecting methods.

The Consolidated Gold Fields of South Africa, Ltd., Premium of Forty Guineas for 1953 has been awarded to MR. RALPH DANIEL for his paper entitled " Diamond mining practice in Kimberley, South Africa."

The Arthur Claudet Student's Prize for 1953 has been awarded to MR. THOMAS ANDREW HENDERSON for his part authorship of the paper entitled " Some exploratory experiments on the formation and control of magnetite during copper smelting operations."

The William Frecheville Student's Prize for 1953 has been awarded to MR. CYRIL LIONEL HALL for his part authorship of the paper entitled " Laboratory tests on the concentration of witherite from the Northern Pennines by froth flotation."

Royal Society Rutherford Memorial Appointments

UNDER the terms of the scheme to commemorate the late Lord Rutherford of Nelson the following appointments are announced by the Royal Society.

Rutherford Memorial Lecture—The Council of the Royal Society has appointed Dr. E. Marsden, C.M.G., C.B.E., F.R.S., of New Zealand as the Rutherford Memorial Lecturer for 1954. Dr. Marsden is delivering a series of lectures at university centres in South Africa.

Rutherford Scholarship—The Council of the Royal Society has appointed Mr. D. M. Brink, a graduate of the University of Tasmania, as a Rutherford Scholar for three years from 1st October, 1954, to carry out research in nuclear physics at the Clarendon Laboratory, Oxford.

Conference on Open-Hearth Flames and Output

A ONE-DAY conference on " Open Hearth Flames and Output," organised by the West of Scotland Iron and Steel Institute, will be held on Friday, 10th September, 1954, at the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow. Two groups of papers will be presented in the morning. Group I will comprise " Combustion and Radiation Characteristics of Oil and Coke-Oven Gas Jet Flames," by Prof. M. W. Thring (Sheffield University); and " Melting Rates in the Open Hearth Furnace," by E. J. Burton (B.I.S.R.A.). Group II will include three papers: "Improvements in Firing Oil and Coke-Oven Gas in the Open Hearth Furnace," by J. A. Leys (B.I.S.R.A.); " Making Producer Gas a Competitive Fuel," by G. W. C. Allan (B.C.U.R.A.); and " The Use of Various Fuels in the Open Hearth," by W. B. Wright (Colvilles, Ltd.). The afternoon session will be devoted to a general discussion opened by Mr. R. W. Evans (Steel Co. of Wales), who is chairman of the B.I.S.R.A. Steel Practice Committee.

Further particulars may be obtained from the Secretary of the West of Scotland Iron and Steel Institute, 39, Elmbank Crescent, Glasgow, C.2, to whom applications for enrolment should be sent not later than 31st August.

J. H. Andrew Fellowship

THROUGH the generosity of the English Steel Corporation, Ltd., Thomas Firth and John Brown, Ltd., and Firth-Vickers Stainless Steels Ltd., the University of Sheffield has been able to establish the J. H. Andrew Research Fellowship in Metallurgy. The Senate of the University has now made the first award of this Fellowship to Mr. R. G. Ward (B.A., Cambridge). After a period as a technical apprentice at the Royal Aircraft Establishment, Farnborough, Mr. Ward was awarded a Technical State Scholarship to Cambridge University where he graduated in 1951, with First Class Honours in Part II of the Natural Sciences Tripos, (Metallurgy). He was elected a Bachelor Scholar of Christ's College, Cambridge in 1951, and since that date has been a research student in the Department of Metallurgy at Cambridge University, working under the direction of Dr. T. P. Hoar. It is hoped that Mr. Ward will be able to take up his tenure of the Fellowship on the 1st July, 1954.

Structural Aluminium Research Scholarship

THE Institution of Structural Engineers has accepted an offer by The Aluminium Development Association of a Research Scholarship to the value of £400 a year to enable the holder to undertake research on some aspect of the application of aluminium alloys to structures. The Scholarship will be awarded in alternate years for a two year period. It is the intention of the Council of the Institution to make the first Award in the near future in order that the successful holder may commence his investigations in October. Entries for the Scholarship to be awarded this year close on July 15th. The Scholarship is to be administered by the Institution, and further particulars, together with forms of entry, should be obtained from the Secretary of the Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1.

Extension to Patent Office Library

IMMEDIATE open access to over 3,500 scientific and technical periodicals in all languages has been provided by a new extension to the Patent Office Library, which is now open to the public in the basement of the headquarters building in Chancery Lane, London. All of this periodical material, which ranges over the whole field of technical invention from agriculture to zinc, will now be conveniently arranged on open shelves. It will cover items published since 1920. Hitherto much of

it has only been available on request. Earlier volumes will continue to be supplied on demand. Another important addition will be the provision of a special section for bibliographies and abstracts—indispensable keys to the searching of scientific literature.

The extension has been made possible by a general re-arrangement of the library, and by overhauling the wartime accumulation of unbound volumes. These arrears have been reduced from 22,000 to 14,000 in the past three years and will be further reduced to 10,000 by the end of this year. The Patent Office Library, a reference institution of international repute, was established in the mid-nineteenth century, has a total stock of 360,000 volumes and is open to the public until 9 p.m. Monday to Friday, and until 5 p.m. on Saturday. It is visited by nearly 2,000 people a week.

New B.S.F.A. Chairman

MR. F. N. LLOYD, Chairman and Managing Director of F. H. Lloyd & Co., Ltd., Steel Founders, of James Bridge Steel Works, near Wednesbury, was elected Chairman of the British Steel Founders' Association at their Annual Meeting in London last month. He has for the past two years been Vice-chairman of the Association, and has also been a member of its Executive Council from the foundation of the Association some 10 or 11 years ago. Mr. Lloyd has always played a prominent part in the activities of the Association and especially those which have been concerned with improving steel founding techniques. When the Association originally formed its Research and Development Division, Mr. Lloyd was a member of its Council and later, when it became the British Steel Castings Research Association, he was the first Chairman of Council.

A presentation made by members of the Association to the retiring Chairman, Mr. T. H. Summerson, took the form of two landscapes by the 19th century artists G. F. Watts and E. J. Niemann. Mr. Summerson was also handed an illuminated address acknowledging the services that he had rendered to the Association during his period of office. In addition to his numerous business interests, Mr. Summerson is High Sheriff of the County of Durham and Chairman of the Home Affairs and Transport Division of the Association of British Chambers of Commerce.

Travel for Educational Purposes

RESIDENTS of member countries of the Organisation for European Economic Co-operation will have greater facilities for visiting other member countries to pursue academic or profession studies and to attend educational centres, as a result of the adoption by the O.E.E.C. Council of further liberalisation measures regarding invisible transactions. From now on, for a period not exceeding one year for each payment, member countries will authorise the transfer of sums to cover fees payable for education at a university, a vocational college or, up to a reasonable amount, at a secondary or primary school. They will also authorise the transfer of the necessary sums for the payment of living expenses.

This decision has considerably improved the position, as up to now member countries simply undertook to treat requests for transfers in as liberal a manner as possible. The new decision makes it compulsory for them to permit such transfers. It applies to all O.E.E.C. member countries except France, Greece, Iceland and Turkey, which, owing to their balance of payments deficit or their economic situation are authorised provisionally not to apply the provisions of the Code of Liberalisation as regards invisible transactions. Italy and Sweden, moreover, have indicated that they are not at the moment in a position to adopt this decision, although their policy in this respect is very liberal ; the position of those two countries will be reconsidered by the Council in six months' time.

Personal News

MR. E. W. VOICE, Assistant Director of the Central Research Establishment (II) of the National Coal Board at Isleworth, has been appointed Head of the Ironmaking Division of the British Iron and Steel Research Association, in succession to DR. H. L. SAUNDERS, who has retired because of ill-health. From 1946 to 1951, Mr. Voice was a member of the staff of the Ironmaking Division, and was in charge of the field team at the Association's North East Coast Laboratories when he left.

MR. W. H. MCFADZEAN, Deputy-Chairman and Chief Executive of British Insulated Callendar's Cables, Ltd., has been elected Chairman of the Company on the retirement of SIR ALEXANDER ROGER, K.C.I.E. Mr. McFadzean has been with B.I.C.C. and the former British Insulated Cables Company since 1932.

MR. D. L. POLLOCK has joined the Board of Vickers, Ltd. Mr. Pollack is a Director of S. Pearson & Son, Ltd., Legal and General Assurance Society, Ltd., Westminster Bank, Ltd., and other companies.

THE Board of Trade announces that the President has appointed MR. R. L. WALSH, Master Cutler, to be a member of the Council of Industrial Design.

MR. R. G. HULL, Manager of Northern Aluminium Company's Manchester Sales Office, retired on 1st June, after 26 years service with the Company. He is succeeded by MR. D. A. CORBETT-THOMPSON, who was formerly on the staff of the London Sales Office.

FOLLOWING the transfer of the resistance welding business of British Insulated Callendar's Cables, Ltd., to Metropolitan-Vickers Electrical Co., Ltd., MR. A. H. LAWSON, who was responsible for the welding machine department at Prescot, has now joined the Metropolitan-Vickers staff at Trafford Park as Sales Engineer.

DR. J. W. CUTHBERTSON, Assistant Director of Research at the Tin Research Institute, has been elected to the Cripps Chair of Metallurgy at Nottingham University. Dr. Cuthbertson was on the staff of the Metallurgy Department at Manchester University from 1928 to 1944.

MR. G. P. CLAY, Chief Engineer of the Metals Division of Imperial Chemical Industries, Ltd., has been appointed to the Board of the Division.

Obituary

WE regret to record the death on 15th May, of MR. D. D. HAWLEY, M.C., a Director of Hadfields, Ltd. He was 59 years of age and was appointed Sales Director in February of this year. Mr. Hawley, who joined the Company in 1919, was a Member of the Executive Council of the British Steel Founders' Association, and a Director of Ernest Newell & Co., Ltd.

RECENT DEVELOPMENTS
MATERIALS : PROCESSES : EQUIPMENT

Diaphragm Units for Automatic Contol

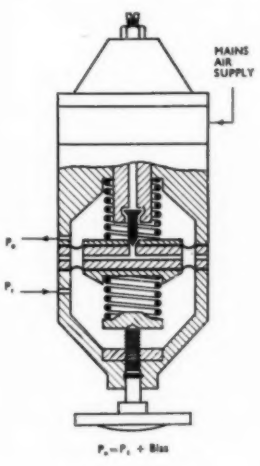
THE application of automatic control to processes which require composite-control schemes has necessitated the development of auxiliary pneumatic apparatus to work in conjunction with the basic single- or multi-term controller unit. George Kent, Ltd., are manufacturing a range of diaphragm units to extend the operation of their Mark 20 class of controllers in their normal performance when used in composite-control schemes; and are making these units available for general use in the process-control field. The units are fitted into a control circuit where it is necessary to alter the magnitude of the control signal or combine two or more signals. The input and output signals are in the usual 3–15 lb./sq. in. range, and the output signal from the unit is accurate to within $\pm 0{\cdot}2$ lb./sq. in. of its theoretical value. This accuracy is attained with a high rate of response and complete stability of operation. The range of units includes: (1) load distributor; (2) 2-to-1 relay and 2-to-1 bias relay; (3) 2- and 3-point averaging relays; (4) 2-point summator; and (5) differential summator.

The load distributor provides a means of manually biasing the individual outputs of various sections of a plant while the total output of the plant is being automatically controlled; for example in boiler-control applications where a number of boilers are regulated by one master pressure controller.

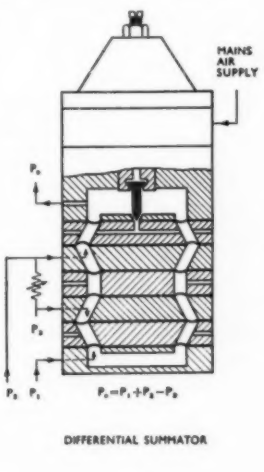
The 2-to-1 and 2-to-1 bias relays can be combined so that one control signal can operate two regulators in cascade, one over the first half of its range and a different regulator over the second half of its range.

Where one control signal is required which bears some relationship to two or more separate variables, summating and averaging relays are used, a typical application being fuel/air ratio control, in which the total air to the furnace is adjusted to control the combustion of two separate fuels being burned simultaneously.

One use of the differential summator is to introduce temporarily into a control circuit the effect of a change in the control signal in another circuit. It is employed for this purpose between two control circuits, one of which can inject a disturbance into the other through the medium of the plant; by helping to counteract this disturbance the unit assists in the control of the variable in the affected circuit.



LOAD DISTRIBUTOR



DIFFERENTIAL SUMMATOR

George Kent, Ltd., Luton.

New X-ray Processing Unit

A NEW X-ray processing unit has recently been introduced by Watson & Son (Electro-Medical), Ltd., for X-ray departments in hospitals and for medical and industrial use in factories. Known as the Watson Processing Unit Type 60, it incorporates several improvements and has a large capacity.

The unit is divided into four compartments. The first is fitted with a thermostatically controlled immersion heater and contains a 10-gallon vulcanised rubber tank with lid, in which the development is carried out. This tank will accommodate films up to 14 × 17 in. (30 × 40 cm.). A similar tank contains the fixing solution in the third compartment. If preferred, one or two 5-gallon tanks can be used instead of the standard 10-gallon tanks. The other two compartments are for rinsing and washing, and have a water inlet at the bottom and an overflow at the top. This ensures that the water is constantly changing, so that the films are efficiently washed. The washing compartment will take up to 35 hangers, these being supported on stainless steel rods. The waste pipes are connected together and extend to the rear of the unit on either side so that the waste can be connected to the existing plumbing at the most convenient point.

The framework is of galvanised steel, lined inside and outside with stainless steel, which is unaffected by the solutions used. The fitments include a laboratory chromium tap with hose connector for filling the tanks, controls for the water supply to the rinsing and washing tanks, and easily accessible draining cocks.

The General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2.

Chlorobromomethane Fire Extinguisher

NU-SWIFT, LTD., the fire extinguisher manufacturers, announce the marketing by them of a new and revolutionary type of pressure-operated extinguisher in which chlorobromomethane, the new fire fighting chemical, is held with absorbed carbon dioxide under constant pressure.

This is claimed to be the first British-made extinguisher in which use is made of the extraordinary fire fighting properties of chlorobromomethane, and details are given of tests carried out on a petrol fire 2 sq. ft. in size, on which an old-fashioned quart-size Nu-Swift hand pump holding carbon tetrachloride failed to extinguish the fire after 40 seconds pumping, while the pressure-operated chlorobromomethane extinguisher, of the same

size, put out a similar fire in 1½ seconds. The scientific explanation of this extraordinary increase in fire fighting power is the low inhibitory factor of chlorobromomethane compared with that of other chemicals in commercial production, while another important factor is the thorough "atomisation" of chlorobromomethane by the carbon dioxide.

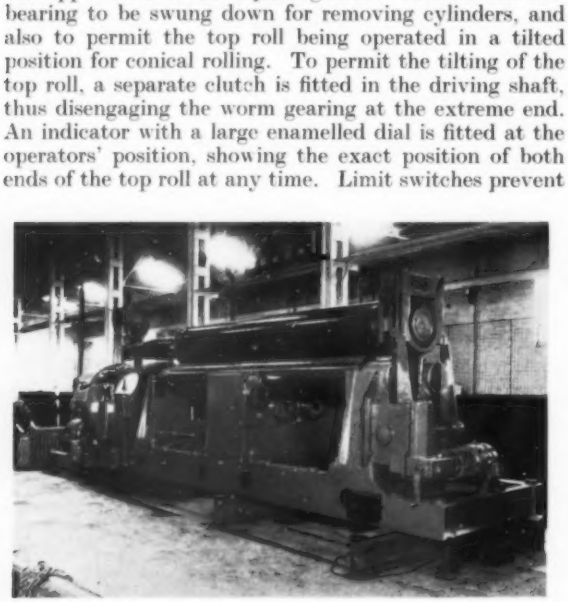
Stated to be particularly effective on extra-hazardous risks, such as electrical equipment like radar, neon signs, television equipment, switchgear, etc.; and medium-sized organic solvent fires of all types common in laboratories, garages, etc.; as well as on spill fires from modern aeroplanes; this extra-rapid extinguisher, less than 16 in. high, is marketed by Nu-Swift, Ltd., under the registered trade name of "Chloro-Flash". For use in the home market, "Chloro-Flash" Model 2003 has been approved by the Fire Offices' Committee, but a large export market is also expected. The sealed pressurised charge makes this type of extinguisher particularly suitable for use in the tropics, while it is also effective at arctic temperatures, as chlorobromomethane freezes only at −120° F. (−86° C.).

Nu-Swift, Ltd., Elland, Yorks.

Plate Bending Machine

Bronx Engineering Co., Ltd., have recently introduced a 3-roll pyramid-type plate bending machine capable of dealing with 12 ft. wide × 1½ in. thick mild steel, with alternative capacities of 9 ft. × 1¾ in. and 8 ft. × 2 in. The rolls are machined from solid forgings in 0·45–0·50% carbon steel, the diameter of the top one being 25 in. and of the bottom ones 19 in. The bottom rolls have grooves machined in the periphey to assist in gripping the plate.

The housings are of fabricated steel construction. The bottom rolls work in bearings with loose caps and the lower parts of the housing contain the worm gearing for adjusting the top roll, and are provided with covers forming an oil-tight case so that the gearing runs immersed in oil. The top roll bearings are pivoted at the upper ends of the adjusting screws to allow the end bearing to be swung down for removing cylinders, and also to permit the top roll being operated in a tilted position for conical rolling. To permit the tilting of the top roll, a separate clutch is fitted in the driving shaft, thus disengaging the worm gearing at the extreme end. An indicator with a large enamelled dial is fitted at the operators' position, showing the exact position of both ends of the top roll at any time. Limit switches prevent accidental overrun of the top roll—either up or down. An extension is provided on the top roll to counterbalance the weight when swinging down the end bearing. The roll support housing is of fabricated steel construction and carries two support rolls to each side roll.



Bronx Engineering Co., Ltd.

Zirconiated Tungsten Electrodes for Argon Arc Welding

New Murex zirconiated tungsten electrodes recently developed for use in the argon arc welding process have the important advantage of greater resistance to contamination than the pure tungsten and thoriated tungsten electrodes which have hitherto been generally used. Electrodes used in argon arc welding are in theory non-consumable, but in practice considerable wastage occurs, mainly owing to the regrinding which is necessary to keep the electrode tip free from contamination.

One of the most important requirements of an electrode of this kind is that it should retain a suitable point during welding in order to limit the width of the weld and to maintain a consistently stable arc throughout the welding operation. These conditions apply only to D.C. welding, and, in particular, to thin sheet welds and high speed automatic welding.

In the case of a pure tunsten rod, contamination means immediate regrinding, because contamination lowers the melting point of the tungsten and deterioration occurs rapidly. It is also difficult to maintain a suitable point with this type of electrode for similar reasons. Thoriated tungsten electrodes, which incorporate thoria to increase their emission, have certain advantages over the pure tungsten type. It is easier to maintain a suitable welding point when using thoriated tungsten electrodes, because they offer greater resistance to contamination than the pure tungsten rods, and they also enable the arc to be re-struck more readily. However, direct contamination either by contact with the molten pool or filler wire necessitates the immediate regrinding of the electrode, and in this respect it has, therefore, very little advantage over the pure tungsten type.

The zirconiated tungsten electrode shows a considerable improvement over the thoriated tungsten electrode in its resistance to contamination. Even if it is deliberately allowed to touch the molten pool and the filler wire during welding, contamination although present, does not "wet" the point of the electrode and form a globule on the tip as in the case of pure tungsten and thoriated tungsten rods. Indeed it is possible to continue welding with zirconiated electrodes after contamination when, in similar circumstances, pure tungsten and thoriated rods would require immediate regrinding.

Zirconiated electrodes are slightly higher in price than the tungsten types, but apart from economies in material and labour there is the equally important point of considerably less interruption in the flow of work. Murex centreless ground zirconiated tungsten electrodes are now being made in diameters ranging from $\frac{1}{16}$ in. to $\frac{5}{32}$ in. (in $\frac{1}{32}$ steps), and lengths of 6 in. and 8 in., with the addition of a 12 in. rod in the $\frac{1}{16}$ in. diameter size. Supplies are at present limited.

Murex Welding Processes, Ltd., Waltham Cross, Herts.

CURRENT LITERATURE

Book Notices

THE DIAMOND TOOL INDUSTRY IN 1953

7 × 9¼ in., 8 pp. Issued by the Industrial Diamond Information Bureau, 32–34, Holborn Viaduct, London, E.C.1. Free of charge.

THIS report, the ninth in succession, summarises the main developments during the year 1953. The following fields are reviewed: diamond as a material, properties of diamond, synthesis of diamond, hardness and microhardness, surface finish, fine boring and fine turning, trueing of grinding wheels, diamond powders, impregnated diamond tools, sintered carbide grinding, glass grinding and stone working, rock drilling, wire drawing, diamond use and salvage, new machining methods, and jewel bearing production. With each section references are given to the literature, a total of 155 references being quoted. This year's report refers in particular to new developments in hardness and microhardness testing, diamond powders, impregnated diamond tools, and diamond use and salvage. The report will be of interest to all those engaged in the use and production of diamond tools. This summary is mainly based on a monthly bibliography that has been published for 10 years by the same organisation. Copies of the bibliography can be obtained, free of charge, by those interested in the diamond and diamond tools.

PROJECTION WELDING OF MILD STEEL

14 pp. with 11 illustrations and many tables. Published by the British Welding Research Association, 29, Park Crescent, London, W.1. Price 3s. 6d.

PREPARED by a Committee of the British Welding Research Association composed of resistance welding experts from the industry of Great Britain, this informative booklet covers all aspects of projection welding and is the first available in this country which deals solely with this subject. Recommendations are made to cover machines and electrodes, materials to be used, types of projections, and machine settings for various thicknesses of material. All are prepared from a series of extensive researches conducted by B.W.R.A. during the past five or six years. The booklet concludes with a section on suggested practices for projection welding based on present industrial experience.

KEMPE'S ENGINEERS YEAR BOOK

Two volumes, crown 8vo, 3,000 pp., 1,500 illustrations. Morgan Brothers (Publishers), Ltd., 28, Essex Street, Strand, London, W.C.2. 75s. (by post 77s. 6d.).

As a reference book, Kempe's has for long been notable for the extremely wide range of subjects covered, and in the 1954 edition recently published, the range has widened still further. Every chapter (except that on gearing, the revision of which awaits the conclusion of the work in hand on the subject by the British Standards Institution) has received a major revision and been brought up to date. On some subjects, the large amount of additional matter which has been introduced has resulted in what are virtually new chapters. So much new metallurgical information has been incorporated that the original chapter has been divided into three, dealing with iron and steel non-ferrous metals, and foundry practice, respectively. In other fields, repetition has been avoided by bringing together chapters originally separate. Marine oil engines and marine steam engines are now dealt with together in a chapter on marine engines, whilst heating and ventilating, formerly separate chapters, are discussed together in a section on heating, ventilation, and air conditioning.

Despite these combinations, the new edition has a total of 79 chapters, in comparsion with the 70 in earlier editions. This is mainly due to the fact that there are eight new chapters, on atomic power, explosives, electrical engineering fundamentals, industrial safety, mechanical handling, plastics, powder metallurgy and theory of structures. The index has been made more comprehensive and now contains 17,000 references against the 12,000 formerly. A carefully prepared bibliography is included in those chapters which call for one.

Trade Publications

As an introduction to an illustrated brochure issued by Magnesium Elektron, Ltd., Clifton Junction, Manchester, entitled, "Weight Control with Elektron" some figures are given, based on the findings of the Weight Control and Power Plant Weight Panels of the Society of British Aircraft Constructors, for the value to the operator and the cost to the manufacturer of weight saving. The brochure goes on to point out that weight control begins with material selection, and recommends a start with a specific gravity of 1·8. In the following pages, special emphasis is laid on the magnesium-zirconium alloys which are available in the forms of castings, sheet, extrusions and forgings.

A NEW data book on the choice and use of hacksaw blades has recently been published by English Steel Corporation, Ltd. Apart from the general information and guidance, details are given of the types of blade available in the E.S.C. Cyclone range, and recommendations are made as to the most suitable blades for cutting different materials, both by hand and machine.

NON-FERROUS finned tubing for use in heat exchangers, such as intercoolers or air-cooler condensers, offers important advantages over plain tubing in heat-transfer performance where the inside and outside heat-transfer media have markedly different film coefficients. For liquid-to-air combinations in particular—hot-water air heaters, oil and chemical coolers, refrigeration units—increased surface area per foot run is highly desirable. Finned tubing provides a substantial increase in the ratio of external to internal surface area and, by its compactness, offers considerable economies in construction and maintenance. A recent publication of the Metals Division of Imperial Chemical Industries, Ltd., deals with "Integron," which is a finned non-ferrous tubing in which tapered helical fins, at right-angles to the centre line of the tube, are produced by rotary cold forming from the body of the original plain tube. The process employed permits the manufacture of finned tubes of various diameters, fin heights, fin spacings and lengths. There are two forms of "Integron" tubing:

the low-fin type is available in copper 70/30 or 70/29/1 brass, aluminium brass, 'Kunifer' 30 and 30A, and aluminium and aluminium alloys. Fin spacing is 19 per inch. The high-fin tubing is available in copper only, but the range will shortly be extended to cover the other alloys mentioned above. Fin spacing is 4, 6, 7 and 8 fins per inch. A companion leaflet deals with "Integron" low fin tubing for use in Freon-12 water cooled condensers. These condensers are used for the most part in conjunction with reciprocating and centrifugal compressors for refrigeration purposes. The booklet provides details of the size and metals normally used, and the means of calculating the linear footage requirements in such condensers.

THE leading article in the latest issue of Wiggin Nickel Alloys (No. 26) deals, in some detail, with the operating experience obtained with Nimonic alloys in de Havilland Ghost engines. A further article shows the use of these materials in the Pratt & Whitney J-42 Turbo-Wasp, the American equivalent of the Rolls-Royce Nene gas turbine. Other articles deal with the Bristol Instrument Company's use of Monel in their convertible thermometer bulbs and of the use of this corrosion-resistant alloy to protect steel piling exposed to sea-water attack. Another example of the successful use of this alloy is for a solution reboiler used in the removal of hydrogen sulphide in the amine treating process. A detailed account is given of the Free Pendulum Astronomical Regulator made by the Synchronome Co., Ltd., in which Nilo 36, a special nickel-iron alloy with a very low coefficient of expansion, is used for the slave pendulum and for the bob of the controlling pendulum. Copies may be obtained free of charge on application to the Publications Department of the Company at Thames House, Millbank, London S.W.1.

WE have received from the Morgan Crucible Co., Ltd., a leaflet describing the Morgan high temperature, lightweight, low heat storage, M.I. 22 Insulating Concrete, which has a maximum service temperature of 1,200° C. It is supplied dry and requires only the addition of water when, like structural concrete, it can be cast or poured into position. It provides insulation equivalent to approximately double its thickness of ordinary firebrick, and is already proving itself in service as an insulating layer between refractory and furnace shell, in hot air ducts, and in recuperator and regenerator passages. A special grade for application by "gunning" has also been developed, known as M.I. 22 Insulating Concrete "Guniting" Mix.

FOLLOWING the acquisition of Sheffield Forge and Rolling Mill Co., Ltd., and the installation of a new electric arc furnace at the works of Andrews Toledo, Ltd., the Darwins Group is now in a position to offer a considerably extended range of rolled and forged bars and a comprehensive range of quality steels. This situation is reflected in the pages of a recently issued booklet, which lists the Group's products. They include carbon steels, low and medium alloy steels, nitriding steels, spring steels, valve steels, file steels, stainless steels, heat resisting steels, tool steels, thermal expansion alloys, and glass-to-metal sealing alloys.

A SIX-PAGE brochure issued by Radford Electronics, Ltd., 149, Newfoundland Road, Bristol, 2, describes a range of stock type transformers for use in the electronics industry. The range has been produced as a result of many year's experience, and it is felt that it will fill the need in research and production for a range of transformers for continuous duty at full load ratings under extremes of climatic conditions.

WE have received from Monometer Manufacturing Co., Ltd., 115–116, Strand, London, W.C.2, their latest leaflet dealing with Monometer metal melting furnaces which can be arranged for oil or gas firing. The leaflet shows pictorially the types of furnaces made by the Company. These include rotary furnaces for ferrous and non-ferrous melting and refining, semi-rotary furnaces, hot metal receivers for use in conjunction with cupolas in iron foundries, bale-out furnaces for die-casting, tilting and lift-out crucible furnaces, transfer ladles for feeding bale-out furnaces, valve outlet furnaces for low melting point alloys, and white metal pressure casting plants for lining railway carriage and wagon bearings.

WE have received from W. Edwards & Co. (London), Ltd., of Manor Royal, Crawley, Sussex, a series of new leaflets dealing with their vacuum products. B.118/1 gives full details, including speed curves and a specification table for the complete range of oil and mercury diffusion pumps, from small laboratory models to the 24 in. industrial pump, whilst Edward's re-designed mercury and oil monometers are shown in D.143/1. Considerable time is often spent by skilled workers in research and industry in "making up" articles for use in various processes: full details are given in E.144/1 of evaporating filaments, baskets and boats for use in vacuum coating. During the initial experimental work, and later for the actual production of the Circseal range of ground glass cone joints, several useful glass working machines were developed, and one of these, a small lathe, which obviously would be useful in many establishments, is described in E.148/1. Finally, E.149/2 deals with a simple and inexpensive machine designed for vacuum moulding of thermoplastic sheet. The Speedwire 18450 pump unit fitted displaces 15 cu. ft./min. of air, and thus enables very rapid forming cycles to be performed.

A RECENT publication of the Northern Aluminium Co., Ltd., "How to Build a Roof," describes the construction of various types of roof using a new building material in the form of deep-troughed aluminium sheeting known as Rogerstone Building Sheet. It was initially developed for the construction of frameless houses for use in the tropics, and its success has led to the decision to market it here. The hard-temper sheet is stiffened by flat-sided corrugations at 7½ in. pitch, with the sides inclined at 45°, a form that confers maximum adaptability for constructional purposes. Instructions are given of the procedures to be adopted in working with this material, and detail descriptions are given to typical structures incorporating it.

Books Received

"Minerals for the Chemical and Allied Industries." By Sydney J. Johnstone, O.B.E., B.Sc. (Lond.), F.R.I.C., M.I.M.M. 692 pp. inc. appendix and index. London, 1954. Chapman & Hall, Ltd. 75s. net.

"A Text-Book of Metallurgy." By A. R. Bailey, M.Sc., A.I.M. 560 pp. inc. numerous illustrations and index. London, 1954. Macmillan & Co., Ltd. 30s. net.

LABORATORY METHODS
MECHANICAL · CHEMICAL · PHYSICAL · METALLOGRAPHIC
INSTRUMENTS AND MATERIALS

JUNE, 1954 Vol. XLIX, No. 296

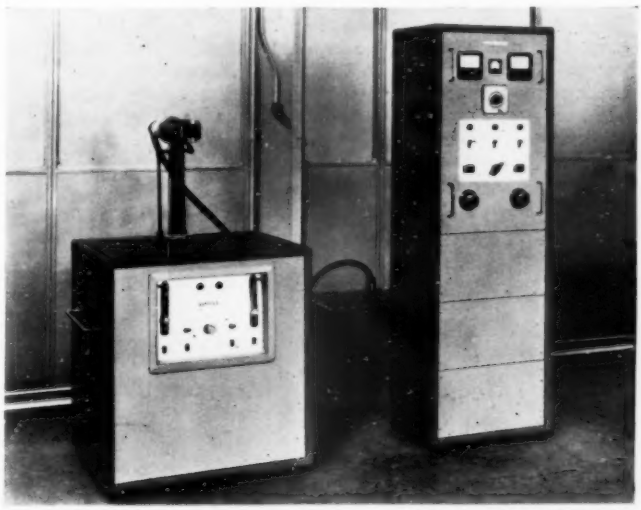
Exhibits of Metallurgical Interest at the Physical Society Exhibition

The exhibits at the Physical Society's annual exhibition of scientific instruments usually include a number of interest to workers in the metallurgical field. This year was no exception and in this issue we begin a short series of reviews in which such items will be described.

X-ray Diffraction Unit

IN the Newton Victor Raymax 60 X-ray Diffraction Unit, a new design of apparatus rated at 60 kVP, the barest essentials of crystallographic facilities are available at a cost which has been minimised by the provision of a simple and compact apparatus without inessentials or specialised refinements, but to which can later be added particular components and devices required for the carrying out of all the more complex crystallographic techniques and procedures.

A primary design feature of considerable importance is the separation of the equipment into three components: a continuously evacuated X-ray tube, mounted above a high vacuum pumping plant; a high-voltage transformer; and a vertical control panel. This arrangement gives greater flexibility in installation and makes it easier to meet stringent protection requirements, especially where it is more convenient to have the control panel outside the lead-lined cubicle.



Courtesy of Newton Victor, Ltd.

Raymax 60 x-ray diffraction unit

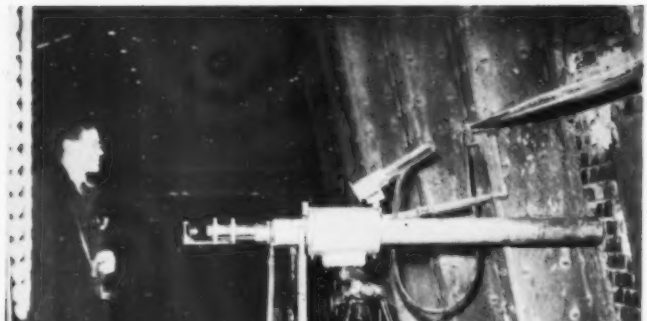
The demountable-type continuously-evacuated X-ray tube incorporates a newly designed cathode assembly with a negatively-biased focussing shield which, in conjunction with the bar-line filament, ensures a sharp focus of 10mm × 1mm (or less) on the tube target. The anode is of a new design, providing unique facilities for the rapid interchange of target materials. If the target is to be changed frequently, a vacuum valve can be provided to close the diffusion pump. All the demountable vacuum joints in the entire assembly are precision machined and sealed with neoprene gaskets or "O" rings. For simplicity, the high vacuum pumping plant is not automatic, each phase being initiated manually, and a protective relay and electrical interlocks protect the equipment against accidental damage occasioned by unpredictable occurrences such as the failure of the water supply.

The high-voltage transformer is housed in a small space-saving steel tank. Its output is 60 kVp at 20 mA, the secondary winding being tapped for connection to a kilovoltmeter. A negative-voltage rheostat control for the biased electron gun is also contained in the transformer tank, and is adjustable while the equipment is in operation. The vertical-type control unit, which houses all electrical regulators and switchgear, is designed to take standard Post Office pattern racks so that extra panels for stabilizers for filament and high-voltage supplies, and other electronic gear can be readily added when required.

In this apparatus, the designer's fundamental aim has been to provide an inexpensive and simple, but high-quality equipment to which can be added the auxiliary components and refinements necessary to meet the most diverse requirements of the individual user.

Furnace Scanning Periscope

The most vulnerable part of the open hearth steelmaking furnace is the roof, which is normally constructed of silica brick. Its melting point is often below the temperature of the flame which melts the charge, and which burns immediately below the roof. By careful



Courtesy of the British Iron and Steel Research Association

Furnace scanning periscope

Courtesy of Electronic Instruments Ltd.

Automatic pH titrimeter

regulation of the charge, however, the melter can ensure that most of the heat of the flame is drawn down into the hearth and so avoid melting or " running " the roof.

Most modern furnaces are equipped with roof pyrometers, which give a constant record of the temperature at certain parts of the roof. In some cases, if the roof gets too hot, an automatic device cuts down the fuel supply to the furnace. The life of a furnace roof is usually from three to six months, the bricks being slowly worn away, partly by melting and partly by the scouring action of gases, which carry fumes of ferrous oxide which erode silica.

This erosion takes place at different rates in different parts of the roof, and when the furnace is re-built for its next period of service, it is very desirable to know the nature and extent of the wear. Although much information can be gathered from the furnace as it is dismantled, it is important that the erosion should be observed while the furnace is actually in operation. The construction of the open hearth furnace is such that it is impossible to examine the whole of the roof by the unaided eye from outside. Normally only certain parts of the roof are visible through the doors, but a roof scanning periscope has been designed by the British Iron and Steel Research Association, which makes it possible to see not only the whole of the roof, but the entire inside of the furnace, while the furnace is in operation.

The instrument which is 6 ft. long, is mounted on a wheeled trolley. A water-cooled jacket of mild steel, $4\frac{7}{8}$ in. in diameter, protects it from the intense heat—sometimes more than 1,600° C. Three small holes, with heat resisting windows, in the nose of the water jacket, admit light to the optical system, which consists of a reflecting head unit with a concave mirror and a partially reflecting plate. Three adjacent zones of view are covered, selection being effected by moving a single control, which operates the reflector plate. The first zone covers from 0° to 40°, 0° being the direction in which the barrel of the instrument is pointed. The neighbouring zones extend from 40° to 80°, and 80° to 120° respectively. A " slice " 120° × 36° can therefore be seen without moving the periscope tube.

When the tube is rotated on its axis, the " slice " can be moved so that the whole of the roof, or the whole inside of the furnace if necessary, can be scanned. In addition, as the view extends 30° back from a line at right-angles to the barrel of the instrument, the wall through which the periscope is inserted can also be viewed. Initial trials and photographs have shown that the system gives a very clear picture. 16 mm. films have also been taken through the periscope, from a number of viewpoints, showing the furnace in operation, with the burner flame and bath of molten steel. Although devised primarily for investigating the distribution of temperature over the furnace roof, the instrument can, therefore, be used for visual, photographic and cinematographic examination of any point in the furnace.

The roof temperature could be determined over a large area by measuring the photo-density of a photographic image but, as there are no speedy techniques for doing this at present, the possibility of measuring the temperature by incorporating a photo-electric element in the instrument is being considered. Meanwhile, it is planned to use the periscope on a number of studies, including the melting of scrap and the behaviour of the burner flame. Believed to be the first research tool of its kind for the open-hearth furnace, it would also be useful to the glass-making industry.

Automatic Titration

The Automatic *p*H Titrimeter (Model 24) made by Electronic Instruments, Ltd., is based on a design for automatic titration equipment devised by R. Andron (Kodak—Pathé) and D. T. R. Dighton (Kodak, Ltd.), which was shown at the International Congress on Analytical Chemistry, Oxford, 1952. It consists of an electrode system coupled to a mains-operated *p*H control unit, which in turn operates a special tap fitted to an automatic burette. The tap is so designed that it can take up three positions. In the " off " position, the burette is closed completely ; in the " fast " position it flows freely ; and in the " slow " position the flow is reduced to some 0·2 ml./sec.

The position of the tap is governed by a solenoid coil which fits over the burette, and which is energised electrically by the *p*H control unit. The first signal changes the tap from " fast " to " slow," and the second one closes it completely. The principal control is a large dial and pointer which reads over an engraved transparent scale calibrated in *p*H units and in millivolts. On each side of the dial is a lever key ; one marked Automatic : Fast/Slow, and the other one Manual : Fast/Slow. There are also a number of preset controls which are not required during routine titration work, once the control unit is set up.

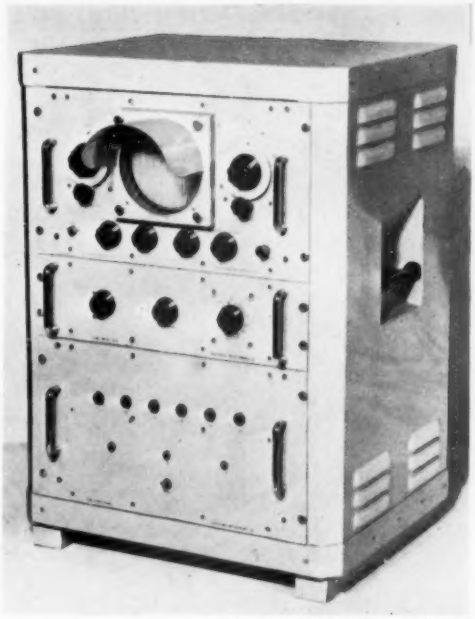
The automatic burette, with its associated reagent vessel, is mounted on a special stand incorporating an electro-magnetic stirrer. The stand also carries the electrode holder and glass beaker. The *p*H control unit and electrode are first standardised in a known buffer solution, and the long-term stability of the amplifier is such that no further resetting should be required in a normal day's work. Once the instrument has been standardised, the control unit dial is set to the desired end point with both lever keys in the " off " position. To set the burette in action, the automatic lever key is moved to the " fast " position and reagent begins to flow freely. As the *p*H approaches the end point the flow is slowed down and the reagent admitted drop by drop until the the end point is reached, when the burette tap is closed. The reading can be taken at the operators convenience and it will be seen that he can thus set up and supervise a number of simultaneous titrations. Furthermore he can carry out titrations on turbid or opaque solutions when indicators cannot normally be used.

Cathode Ray Polarograph

The polarographic method has found applications in all branches of research and analysis, as indicated by the extent of the literature which now exceeds 3,000 papers. The use of the cathode ray oscillograph to display the relation between two variables is well-known, and many suggestions have been made for adapting it to display the current-voltage relations in the polarographic cell.

The K 1,000 Cathode Ray Polarograph developed by Southern Instruments, Ltd., is based on the design of H. M. Davis (British Patent Application 15139/51). In this type of polarograph, the entire change of potential is effected during the lifetime of a single mercury drop, instead of being spread over the lives of many drops as in the conventional instrument. The potential sweep is applied through a load resistor in series with the cell by means of a compensation circuit which maintains a constant rate of change of potential across the cell, irrespective of the voltage drop in the load resistor. The potential difference existing across the cell is amplified and applied to the X-plates of a long after-glow cathode ray tube. The voltage appearing across the load resistor, which is proportional to the current flowing in the cell, is similarly applied to the Y plates. The cathode ray tube spot is thus caused to trace out the polarograph curve on the screen of the tube.

In front of the 6 in. diameter cathode ray tube, is a gratciule calibrated in millivolts, the zeros of both scales being at the bottom left-hand corner. The horizontal scale, corresponding to sweep voltage, is calibrated from 0 to 500 millivolts, and the vertical scale, corresponding to the voltage drop across the load resistor, from 0 to 20 millivolts. The latter figure, in



Courtesy of Southern Instruments Ltd.

K1,000 cathode ray polarograph

conjunction with the selected value of load resistance, enables the cell current to be calculated. During the first five seconds of the life of each drop, the spot remains stationary at the zero point and then moves across the screen during the final two seconds, tracing out the polarographic wave. This remains visible for several seconds, giving ample time for a reading to be taken. The wave differs from that produced by a conventional polarograph in that the current rises to a peak before falling exponentially to a constant value. The height of the peak is strictly proportional to concentration, and it is in fact this peak height which is measured when taking a reading. The shape of the wave does not lend itself to an accurate determination of half-wave potential. A permanent record may be obtained, if desired, by photographing the screen of the cathode ray tube, but this is not usually necessary.

A feature of the cathode ray polarograph is the speed of operation, as the polarogram is displayed on the cathode ray tube every few seconds. Preparatory work is also speeded up, as less chemical separation and concentration is required. Its sensitivity can be up to 100 times that of a recording polarograph and permits accurate determination at concentrations of fractions of a microgram per millilitre. Ions differing in half-wave potential by as little as 0·1 volt may be accurately determined in the same solution. A derivative circuit allows even closer waves to be resolved. Determinations may also be made in the presence of relatively large concentrations of ions reducing at more positive potentials.

These special features are likely to result in the simplification of existing methods and the making possible of a number of determinations not possible in any other way.

Miniature Layer Thickness Meter

The G.E.C. Miniature Layer Thickness Meter can be used for the measurement of thickness of non-ferrous

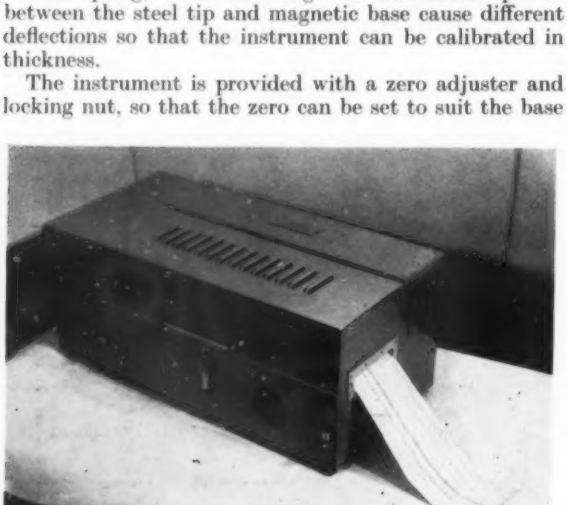
Courtesy of The General Electric Co., Ltd.

Miniature layer thickness meter

layers on cast, wrought, forged or sheet iron and steel bases of permeabilities between 200 and 8,000. It can be used on iron or steel castings, strips, rod or tube, and flat or curved sheets. The minimum sizes on which zero can satisfactorily be set are as follows : (1) sheet iron or steel down to 0·010 in. thick and 2 in. square ; (2) iron or steel strip down to $\frac{1}{32}$ in. thick, $\frac{1}{4}$ in. wide and 10 in. long ; (3) iron rod or tube down to $\frac{3}{4}$ in. diameter and 6 in. long. The minimum concave radius is 3 in., and the minimum convex radius is $\frac{3}{8}$ in.

The instrument is a form of reluctometer operating on the moving iron principle. A specially shaped moving iron is mounted at the neutral axis of a powerful permanent magnet. One end of the magnet projects through the instrument case and is fitted with a spherical tip of hardened steel. The moving iron, which is spring controlled, and has a partially suppressed zero, takes up a position of equilibrium when the magnetic and control torques are equal and opposite. When the spherical tip is placed on a ferrous plate, the flux distribution is upset and the moving iron takes up a new position where equilibrium is again established. Due to the suppression of the spring, small non-magnetic thicknesses placed between the steel tip and magnetic base cause different deflections so that the instrument can be calibrated in thickness.

The instrument is provided with a zero adjuster and locking nut, so that the zero can be set to suit the base on which it is desired to measure the thickness of the coating. The adjuster is provided to allow for variations in size, thickness and permeability of the bases. A pointer lock in the form of a small push button is provided so that the instrument can be used in out-of-the-way places such as corners of tanks and the undersides of steel plates. The instrument measures approximately $3\frac{1}{2}$ in. × $2\frac{1}{4}$ in. × $1\frac{1}{4}$ in., and has a weight of about 6 oz. Three models are available, suitable for the following coating ranges : (1) 0 to 0·030 in. ; (2) 0 to 0·010 in. ; (3) 0 to 0·005 in.



Courtesy of Southern Instruments Ltd.

Type M732 auto-developer for oscillograph paper

Oscillograph Paper Developer

The Type M732 Auto-Developer has been designed by Southern Instruments, Ltd., for use with their Minirack cathode ray oscillographs and recording cameras. It will develop, fix and dry any length of paper record from a few inches up to 200 ft., and of any width up to 120 mm. It operates under full daylight conditions without a dark-room, so that oscillograph records taken on remote sites, ships, aircraft or vehicles can be immediately available for inspection and measurement.

This machine is arranged for use on a table, and has a box at one end to contain the roll of exposed photographic paper to be developed, a processing compartment that contains the developer tank, fixing tank and drying oven, and a compartment at the back that contains the motor and driving mechanism.

The record is transferred from the camera either in a black cloth bag or in a cassette, and the operator manipulates the roll in the box through black cloth sleeves. The processing compartment has a hinged cover and hinged frame that give easy access to the tanks and dryer. Loading is extremely simple. A paper leader is attached to the record and when the frame and the compartment cover are closed and the drive started, the exposed record is drawn at a uniform speed through the developing and fixing tanks and through the dryer. It emerges from the end of the machine and can be drawn out on the table for examination and measurement or re-spooled by an auxiliary unit.

The developing and fixing tanks are provided with immersion heaters that maintain the temperature constant after an initial heating period of about five minutes. Plug and socket connections are provided for quick operation. The drying elements are arranged above and below the record. The heaters operate from 50 volts AC obtained from an auxiliary transformer unit so that there is no risk of electric shock. The power required is 1·3 kW at 200–240 V.

Company "At Home" to University

THE long and close association of the University of Cambridge with the Cambridge Instrument Company was signalised on Wednesday and Thursday, April 28th and 29th, when the Company held an "At Home" at their works in Chesterton Road, Cambridge, to which invitations were issued to the Professors, teaching staffs, research students, and senior men taking science subjects in the University. During the two days over 700 visited the works, and were entertained to tea. All sections of the factory, and of the research department were open for inspection, and various interesting demonstrations were in progress.

Bureau of Analysed Samples, Ltd.

Ninth General Meeting at York

THE Bureau of Analysed Samples, Ltd., whose Ninth General Meeting was held at York last month, was formed in 1935 to ensure the continuous supply of British Chemical Standards—analytically standardised samples of irons, steels, non-ferrous alloys, etc.—which had previously been undertaken by Messrs. Ridsdale & Co., since the movement was founded in 1916 by the late C. H. Ridsdale, F.I.C. The Bureau is unsupported by any grant and relies for its recognition solely upon the value of its work.

With the exception of the pure reagents and metals, each of the standard samples is analysed before issue by at least eight analysts representing referees, users and makers. The standards are prepared under rigorous laboratory conditions, and are issued by the Bureau under the auspices of an Honorary Advisory Committee and a body of over one hundred co-operating analysts and firms. A certificate of analysis giving the co-operating analysts, the types of methods used, and the individual results of each analysis is supplied to each purchaser.

Progress Report

In presenting his report on the ninth period of working, from December 1st, 1949 to November 30th, 1953, Mr. N. D. Ridsdale, Managing Director, said that it had been possible during the period to carry out some of the recommendations made at the previous General Meeting in November, 1950. Standards issued in response to suggestions then made included B.C.S. Nos. 174, 248 and 249—basic slags standardised for total sulphur; B.C.S. No. 246—a stainless steel containing niobium, but low in carbon and copper content; B.C.S. Nos. 262 and 263—aluminium alloys containing magnesium to specifications D.T.D. 300 and D.T.D. 165; B.C.S. Nos. 230 (rechecked), 264 and 265—a series of one low alloy and two straight carbon steels containing increasing amounts of nitrogen; and B.C.S. No. 147—a white iron standardised for total carbon and sulphur.

In addition, a " pure " iron (B.C.S. No. 260) had been prepared mainly as a base metal, with accurately determined traces of impurities, which could be used for making known additions of manganese, nickel, chromium, molybdenum, etc.; in preparing graphs for photometric methods of analysis; and for determining the " blank " in the volumetric method for tin. There would also be available shortly a still purer form of iron in the form of granules (B.C.S. No. 149).

Another important series of seven spectrographic standards (designated S.S. 11–17, Mild Steel Residual Series) was in course of preparation in collaboration with B.I.S.R.A. This series contained increments of residuals including, in addition to the well-known elements, several others which are less frequently found in mild carbon steel, such as tungsten, titanium, zirconium, niobium, tantalum, magnesium, lead and boron. The standardisation of this series had, however, only just commenced, and it was likely to be at least twelve months before they were available.

Other new standards in course of preparation included B.C.S. No. 266—a permanent magnet alloy containing niobium; B.C.S. No. 267—silica brick; B.C.S. No. 268—a 5% silicon aluminium alloy to B.S.1490 : LM—16; and B.C.S. No. 269—aluminous firebrick.

During the period under review, B.C.S. No. 150—Armco iron—was re-analysed more accurately by modern methods, in order to increase its usefulness. B.C.S. No. 163—carbon steel—was also analysed recently for phosphorus, so as to have a standard figure near to the 0·05% specification limit, since the supply of earlier carbon steel standards near to the specification limit had become exhausted.

Because of increased demand, stocks had been depleted more rapidly than previously, and some twenty renewals of existing standards were prepared during the past four years.

In future, a new number would not be allocated to a replacement of a given standard, but the original number would be retained, followed by an oblique stroke and a figure 1, 2 or 3 according to whether it was the first, second or third replacement. This course had been adopted because analysts tended to associate a given number with a certain standard sample, and the new system enabled them to recognise a replacement more easily.

An important step was taken in 1952, when it was decided to move to new premises a few miles outside Middlesbrough, where better and larger machine shops were available for turning and milling metal samples, and where better accommodation was also provided for storing, packing and despatch of samples.

In conclusion, Mr. Ridsdale expressed appreciation for the help and guidance given by the many analysts who had assisted in the selection of standards, the supply of raw material and the analytical standardisation. He had been greatly impressed by the care and time taken by many co-operators at a time when they had been under considerable pressure of other work. It should be a matter of satisfaction to them to know that the standards they had helped to establish were not only useful to them but to about 2,000 other laboratories who were helping to control more precisely than ever the manufacture of millions of tons of iron, steel and other materials in this country and abroad.

Sales Trends

Mr. P. D. Ridsdale, Director, said he was pleased to be able to report the continuance of the steadily increasing demand mentioned at the last meeting, together with a substantial increase of the quantity of standards exported. Comparison of the last three years with the three years covered by the last report, showed an increase of 82% in the standards sold during the period. The greatest demand was still for the plain carbon steels, but this was only to be expected owing to the larger tonnage of these steels produced compared with other metals.

There had been a proportional increase in sales of the majority of the existing standards, except for some of the plain carbon steels, notably the 0·3% carbon

material which now constituted only 8·6% of the total sales compared with 10·6% four years ago. This was mainly due to the introduction of new standards, and to the fact that there had been a greater than average increase in demand for certain other standards.

The demand for pure reagents had increased roughly in the same proportion as the demand for other standards, but they consituted less than 10% of the total sales.

Spectrographic standard rods had, since their introduction in 1949, maintained a steady rate of sale until last year when sales more than doubled. This was largely due to a big demand from dealers in the U.S.A. who had discovered that this series (Low Alloy Steel Series—S.S. 1—8) was quite unique, no equivalent being available from the National Bureau of Standards.

During the past four years, standards had been exported to 38 different countries covering most of the world. The chief importing countries were in Western Europe, 8·4% of the total exports having gone to France. India and Pakistan were second on the list, followed by South Africa and Australia.

The export market depended to a great extent on import restrictions, France having removed many of them in recent years, whereas Australia, which headed the list of importing countries in the last report, had imposed restrictions on imports a year or so ago.

There continued to be a steady demand for samples for students in metallurgical analysis, the sales during the period under review having increased by 7% over the previous period. Although such standards constituted some 12% of the total weight of British Chemical Standards sold, their preparation only constituted about 6% of the work of the Bureau, as they were only analysed by one or two experienced analysts, and were not issued with individual certificates.

General Discussion

Following the presentation of the above reports, the meeting was thrown open for a general discussion, and suggestions were put forward for a number of new standards.

In view of the increasing use being made of spheroidal graphite cast iron, it was suggested that a new cast iron standard, or standards, containing magnesium and cerium, should be prepared. It was pointed out that magnesium could be determined spectrographically, and for such a purpose a series of standards could be made. The suggestion was put forward that it would be better to use lanthanum as a check, rather than cerium, owing to the greater sensitivity possible. There was some doubt as to whether the metallurgical ideas regarding spheroidal graphite iron were sufficiently stable for the demand to last for several years, and there was, too, a possibility that difficulty would be experienced in getting sufficient bulk of material of a homogeneous nature for the preparation of a standard, variations in magnesium being a distinct possibility.

There was considerable support for the suggestion that a standard should be prepared for the absorptiometric determination of tungsten in steels. There was a demand for 1–2% and 3% standards free from vanadium and molybdenum, and it was suggested that a series of four or five would be useful. When the question of copper-base spectrographic standards was raised, it was pointed out that a Sub-Committee of the Institute of British Foundrymen and the British Non-Ferrous Metals Research Association were considering the problem, and that there were some difficulties to be overcome. The situation at the moment was a little indefinite. No further progress had been made with regard to aluminium bronze to DTD 197, standardised with respect to aluminium, as it was not certain that a real demand existed.

The suggestion that a tungsten-carbide-base standard containing cobalt should be prepared, was met with the objection that sintered tungsten carbides were not sold on analysis, although such a standard might be useful to the manufacturer and for training personnel.

Permanent Magnet Association

LAST month, Mr. C. E. Webb of the National Physical Laboratory, Teddington, delivered a lecture in Sheffield on the subject of "Magnetic Testing." This was the second in the series of lectures sponsored by the Permanent Magnet Association, inaugurated last year by Professor W. Sucksmith, F.R.S., of the University of Sheffield. The audience, comprising some 200 people was widely representative of the major electrical and metallurgical industries in this country.

Mr. Webb first dealt with the relationship between the magnetic quantities to be measured and the units used. He then passed to a comprehensive review of direct current measurements on both rings and bars, including permeameter and open circuit tests. Alternating current measurements were briefly examined and special attention was given to the various methods of testing permanent magnets, both for basic properties and gap field measurements. A brief survey of the possible accuracy and limitations of the methods concluded the lecture.

At a dinner which followed, Mr. J. B. Peile, the Chairman of the Permanent Magnet Association referred to the continuing need for technical research and development. He stressed the excellent technical co-operation which existed between the members of the Association, and the opportunity and responsibility for development of permanent magnet technique which arose from having such a large proportion of the industry located in Sheffield. The results of this co-operation were manifest in the valuable discoveries made at the Association's own Central Research Laboratories and in those of its member firms.

Physical Society Exhibition Move

CONTRIBUTORS to the Physical Society Exhibition know well that, in spite of the continued kindness and co-operation of the Rector and Governors of Imperial College, the space which can be made available for the use of the Society is of necessity continually diminishing. It is on this account necessary for the Society to sever its long and happy connections with the College, a decision reached by the Council of the Society with real regret at its last meeting.

Arrangements are now on foot for the hiring of the Royal Horticultural Hall for the 1955 Exhibition, where it is hoped the Exhibition can retain its present character and continue to fulfil its service to science and the development of scientific instruments and apparatus. It is expected that the dates of the 1955 Exhibition will be toward the end of April.

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